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I. THE SEA-WEEDS OF YAR-CONNAUGHT, AND THEIR USES.

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On the west of Lough Corrib, the second largest sheet of fresh water in Ireland, forming the north-western part of the Co. Galway, lies the district called Yar or West Connaught. The western portion of this tract, included in the Barony of Ballinahinch, is called Connemara; however, now-a-days tourists seem to have given the latter title to the whole of Yar-Connaught, although the natives still retain the ancient names.

Yar-Connaught lies on the Atlantic Ocean, being on the west and south-west indented by numerous fiords, bays, and cooses, and along its sea-board the fuci vegetate luxuriantly.

The sea-weeds are used for manufacturing into kelp, also as manure for the land, and are locally divided into three classes, which have received as names—1st, *Red weeds,* or the iodine producing plants that grow below the low-water mark of neap tides; 2nd, *Reeshagh,* or the non-iodine producing weeds that grow in similar situations; and 3rd, the *Black weeds,* growing on the rocks between high and low water.*

The first, in the order of importance as sources of iodien, are "Laminaria digitata vera," "L. digitata stenophylla," "L. saccharina," "L. phyllitis," and "Alaria esculenta." The *Black weeds* proper, grow between high and low water; such as "Fucus vesiculosus," "F. nodosus," and "F. serratus," with many others of little importance; besides these are the weeds found in deep waters, that have somewhat the aspect of the Red weeds, and are called *Reeshagh*, namely, "Chorda filum," "Himanthalia lorea," and "Laminaria bulbosa." The last named are burned along with the black weed by fair dealers in kelp, but by others are used to adulterate the red weed, although they contain merely a trace of iodine; sometimes, however, they may be added to compensate for the soluble salts lost from the red weed that has long been exposed to the atmosphere, as the influence of the latter partially decomposes the weed, and the alkaline salts liberated are washed away, including much of the iodine compounds. If this damaged weed is burned alone, the earthy salts and matter in excess from the loss of the alkalies, cause the mass to be comparatively infusible, and very difficult to burn, but by adding "reeshagh" (which is rich in "Ile" (oil), as the natives say, but in reality on account of its containing much of the potash and soda salts) the infusibility of the earthy salts is corrected, and the product is a nice-looking, well-fused mass, yet necessarily poor in iodine. This is the plan usually adopted with damaged red weed; but good burners, instead of using "reeshagh," add to it fresh well-saved red weed, as the latter contains sufficient alkaline salts to flux the earthy salts and matter of the old weed, and form the mass into a kelp containing all the iodine salts of the new weed with whatever remains in the damaged article. Necessarily the product will not have as high a percentage of iodine as if the kelp was manufactured from the fresh well-saved red weed alone; however, the kelp procured from the mixture is found to pay better than if the iodine which remained in the damaged weed were totally lost, and without some flux or another it is unattainable.

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* To John Steven, Esq., of Mullaghmore, the representative of William Patterson, Esq., of Glasgow, I am indebted for the classification of the fuci, and also for many of the statistics in this paper.

Sea-weeds grow much more rapidly in strong tidal ways than elsewhere. In such localities the black weeds arrive at maturity in two years, while in the land-locked cooses, creeks, and bays, where there is a sluggish tide, they will take three or even four years. The growth of the red weeds is also affected by the tide, the plants being more luxuriant in a good race than elsewhere.

The great sea-weed harvests are in the spring and summer months; nevertheless, during the winter the inhabitants of the coasts collect what may be driven in by the tides and storms, which is locally known by the names of "Claddagh," or "Sea-wrack," to spread on the lands they intend to till and crop subsequently. In the spring of the year the great work begins, as the inhabitants then cut from the rocks the two or three year old plants, according to the situations in which they are growing,* and much of this weed they send by boat for sale at Galway, or some of the small towns on the south or east of Galway Bay, from whence it is brought by carts, or even by the railways, into the interior of the country, to be used as a fertilizer for the land; while the "seawrack" that may be driven in during this period, they save by drying in the sun; some to be burned into kelp, while more, later in the year, will be sent away in boats to be sold as manure for the late potatoes and turnip crop.

The burning or kelp manufacture usually begins in the latter end of April, but sometimes earlier, if the spring has been dry and hot, and is carried on until the end of September; however during a fine dry autumn they may keep the fires lighted all October or even November, but this depends entirely on the weather and the quantity of weed they are able to save, as in Yar-Connaught, except in the Aran Islands, the drying process is altogether effected by atmospheric heat.

In former years there was an extensive trade in black weed kelp, as the prices ranged from £15 to £20 a-ton; most of the soda used in the manufacture of soap, glass, &c., being procured therefrom. But the duty having been taken off salt, cheaper methods were resorted to, such as that discovered by M. Lablanc, for obtaining soda from common salt, through its decomposition by sulphuric acid. The adaptation of M. Lablanc's celebrated process rendered black weed kelp almost valueless as a source of soda, and this trade, for soap-making purposes, ceased about the year 1840. Its loss not only affected the inhabitants of Yar-Connaught, but also the people living on the west coast of Scotland, particularly the inhabitants of the Hebrides, whose country, as well as their manner of living, resemble those of Yar-Connaught. From the Hebrides many of the inhabitants emigrated, while in Yar-Connaught the people became poorer and poorer till the famine of 1846 and the following years, during which visitation many of them found a resting-place in their graves.

After the great trade in the black weed succumbed, a new one sprang up in red weed kelp, for obtaining the marine salts, which yield iodine, bromine, &c.; but this trade was not of much importance until after the year 1845, since which it has become annually more and more developed. It should here be mentioned that to William Patterson, Esq., of Glasgow, Yar-Connaught is principally indebted for this source of industry. He introduced and fostered it, and now carries on an enormous trade along the west and north shores of Ireland, from the mouth of the Shannon to Glenarm.

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* The inhabitants of this coast have an ingenious way of saving themselves the trouble of carrying the weed they cut on the rocks, by throwing it as cut in a heap, and, before the tide rises to it, tying it round with a hay or grass rope, locally called a *sūgaun*. This heap rises with the tide, and can be easily towed to whatever part of the shore they wish. This practice seems to have been in vogue for at least 200 years, as it is mentioned by Roderick O'Fflahertie in his history of 'Hiar, or West Connaught,' which was written in the year A.D. 1684.

Of the red weed, that known to botanists as "Laminaria digitata vera" is the principal weed of Yar-Connaught, and of this plant Mr. Steven believes that he has remarked two distinct varieties. "One which sheds its frond early in April and May, and when dried and stacked for a time, does not yield any *mannite;* while the other, parts the frond and *a portion of the stem besides,* in July, and gives out quite as much *mannite* as the 'L. saccharina.' Of the other red weeds some varieties fall in June, July, August, or September, but all the 'Laminariæ' are supposed to shed the frond twice a year."

Doctor Harvey thus describes the separation of the old leaves from the stems:—"As soon as the existing frond has served its purpose and begins to grow brown, an expansion commences between its base and the apex of the stem. This expansion continues to increase in length and breadth till it has attained a considerable size. We have then a large ovate lobe at the apex of the stem, separated by a deep constriction from the old frond. As yet this lobe is quite entire; but after awhile longitudinal splits, commencing near its margin, and continuing towards its centre, begin to appear. These widen and lengthen by degrees, and at last the outer ones reach the decaying base of the old frond; a rupture ensues, and the tip of the new segment is free. This process is continued, until, when many segments have thus been formed, the connection between the old leaf and the now nearly perfect new one is so much weakened, that the former adheres by a very small surface, and is soon cast off altogether."*

The fronds of the red weeds are driven on the shore by the first gale after the plants begin to shed, whereupon hundreds of men, women, and children immediately congregate at the different cooses or small bays to collect the weed driven in, and carry it inland on their own or on ponies' backs. The produce of the spring and summer harvests is usually spread, dried, and stacked to be burned into kelp; while that driven in during the late autumn and winter (unless the weather is extremely fine) is spread on the land as manure for the spring crop. The weed thus treated for manure is supposed by the natives to retain its fertilizing properties, while any which may be left above high-tide mark until it ferments, they consider would be rendered useless. This, however, is controverted by scientific men, as they say "the best way of using sea-weed for manure is to allow it to ferment above high-water mark in alternate layers with either turf-mould or clay, and that the native plan is very wasteful in every respect."

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* 'Phycologia Britannica,' by W. H. Harvey, M.D., M.R.I.A., &c., &c., vol. i., syn. 24.

If the sea-weed is to be used for kelp burning, a gravelly beach (if there be no fine sand) is considered a good place on which to have it driven; but if there is sand the latter will adhere to the weed and cannot be got off even when it is dried, therefore both must be burned together. This deteriorates the kelp, as it adds considerably to its weight, and also decomposes the iodine compounds, which causes some of that metalloid to be volatilized—the former being a loss to the buyer and the latter to the seller.*

The weed having been fully dried, is stacked in heaps until a sufficient quantity is collected, when the fires are lighted. The burning is effected in rude kilns built of loose stones, of which the dimensions are about eight feet long, three wide, and eighteen inches high, the "eye of the kiln" being placed opposite to the wind to catch the draft. This is the plan usually adopted, but in some localities they are made longer and narrower. The best kelp ought of course to be made entirely from red weed; however the operators often mix with it any black weed or reeshagh at hand, more especially "Chorda filum" and "Himanthalia lorea." The price of red weed kelp ranges from 3*l.* to 5*l.* a-ton, according to the quantity of iodine it contains, as all lots are examined previous to purchase by the sulphuric acid test.

When writing of iodine, Apjohn says, in reference to its manufacture,† "The burning of the fuci must not be effected at too high a temperature; for if so, much of the iodides will be volatilized, or decomposed by the silex present in the ash. The kelp, broken into small fragments, is digested with boiling water, which dissolves out the soluble salts, amounting on an average to about half its weight. This solution is then boiled down, until a film forms on its surface, and set to crystallize, when sulphate of soda, carbonate of soda, and a good deal of chloride of potassium, are separated. The mother liquor, which still includes the iodides, mixed with chlorides, sulphides, carbonates, sulphites, and hyposulphites, is heated with one-eighth its bulk of oil of vitriol, when carbonic acid, sulphurous acid, and sulphide of hydrogen are disengaged in the gaseous form, and sulphur is set free. Upon standing, the sulphur subsides, and along with it additional crystals of sulphate of soda. The liquid which remains, and in which the iodine is present, chiefly as hydriodic acid, is then introduced into a large retort, usually made of lead, the beak of which enters the first of a series of three receivers communicating with each other, and finally pulverized peroxide of manganese is added to it through the tubulure. Upon the application of heat, water and sulphate of manganese are formed, and the iodine distils over. The temperature must not rise to 212°; for if it does, chlorine will also be developed, and cause a loss of iodine by converting some of it into chloride. The leaden retort used in this process, and which is of a cylindrical form, is heated through the intervention of sand, and is furnished with two tubulures, through one of which the materials are introduced. The other is placed at about the middle point of the neck of the retort, and serves the purpose of allowing access to the interior of the beak in the event of its becoming plugged with deposited iodine."

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* A wilful fraud committed by the burners on the buyers is the throwing into the mass of kelp, when fluid, lumps of slag procured at the different forges throughout the country; also pounded granite, gravel, &c., all of which add considerably to its weight.

† 'Manual of the Metalloids,' by James Apjohn, M.D., F.R.S., M.R.I.A., &c., &c.

The average quantity of red weed kelp sent yearly from the shores of Yar-Connaught is 2500 tons, and the average price per ton is 4*l*., giving a total of about 10,000*l*. per annum brought into the country.*

If during the spring and summer it is at all favourable weather, and the prices of red weed kelp range from 3*l*. 10*s*. to 4*l*. 10*s*. a-ton, men are enabled to earn from 2*s*. to 3*s*. a-day. The work, however, is very laborious, for, besides the weed driven in on the shores, the kelp manufacturers must supplement the supply naturally brought in by the waves during the summer months, by cutting weed at low-water during spring tides. To do this they go to favourable localities while the tide is high, and the moment the water is low enough, begin operations by one man, with a hook fastened on the end of a long pole, cutting the weed off the rocks at the sea-bottom; whilst another with a pole, having a cross attached, gathers together the weed that floats to the surface, and a woman or boy drags it into the boat. When the tide rises, the boat is rowed to land and the load thrown on the shore for the women and children to carry up and spread out to dry; and as this has to be done twice in the twenty-four hours, while the spring tides last, the work is very arduous. On many of the outlying islands off the coast of Yar-Connaught there are huts which, during the summer months, are inhabited by herds of women, solely for the purpose of carrying up, spreading, and saving the weed thus procured. On such places the kelp is seldom manufactured, but as soon as the weed is saved it is boated to the mainland, or one of the larger islands, and there burned.

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* During the year 1867, which was an unprecedented year, some of the kelp fires not being extinguished till Christmas, there were about 3000 tons bought on the coast of Yar-Connaught. These, at an average of 4*l*. a-ton, give a gross sum of 12,000*l*.

We are told that "the red weed kelp is the only really paying trade; nevertheless, some black weed kelp is manufactured, but it is most unproductive, for, on account of the price for soda, it is never worth more than 1*l*. 10*s*. to 2*l*. 10*s*. a-ton, and even at these prices there is not a good demand for it. Previous to the repeal of the salt duty the soap-maker obtained his alkali (soda) from 'Spanish barilla,' or kelp; Yar-Connaught in those days yielded from 3000 to 4000 tons of black weed kelp annually, and Scotland about 20,000 tons per annum; but now from Prussia and Austria vast mineral supplies of alkaline salts are obtained, therefore black weed or reeshagh kelp, chiefly valuable on account of these salts, are scarcely worth making."

Between the former prices for the black weed kelp (about 15*l*. a-ton) and that now paid for the red weed kelp (4*l*. a-ton) there is a vast difference, and seemingly the former ought to have been the most productive trade. Nevertheless, it was not to the manufacturers, unless they were also the proprietors of the land, for as the black weed grows between high and low water mark the cutters of the weed had to pay a high rent to the proprietors of the land, which considerably diminished the profit on the kelp; while all the red weed grows below low-water mark. However, some proprietors charge a small sum for the right to collect the "claddagh" or "seawrack," and others a royalty per ton for leave to burn the kelp on their shores.

As only a trace of the iodine compounds is found in the black weed, why therefore should they occur in the red weed? And from whence does the latter receive them? Neither of these questions has been satisfactorily answered, nor does their importance seem to have been considered. As the "black weed" is daily lying exposed many hours to the atmospheric agencies, possibly this exposure may be unfavourable to the secretion of the iodine producing salts; this suggestion, however, seems to be controverted by none of these compounds occurring in the "reeshagh" —The "red weed" apparently cannot receive the iodine from any particular rock, as this class grows luxuriantly on granite, gneiss schist, limestone, sandstone, slate, and in fact on every rock found on the west coast of Ireland, even on blocks in the gravel, if they are heavy enough to anchor the weed and prevent it being wafted away by the tidal currents. Iodine is rather rare in nature; Apjohn says "Iodine is found in nature only in a state of combination. In 1811 it was discovered by Courtois in kelp, in which it exists united to sodium and potassium; and it has since been found in combination with the same metal in sea-water, several salt springs, and the ashes of the sponge. M. Bussy has detected it in the coal of Allier, and M. Duflos in the coal of Silesia. Lastly, the iodides of silver and mercury have been met with in Mexico and iodide of zinc in Silesia." In South America salts of iodine occur in some rock masses;[*] and for this reason some *savans* are favourable to the idea, that the American continent is the source of supply to these shores, the Gulf stream acting as the carrier, and that it is on the shores washed by its waters that the iodine producing fuci principally grow. Against this it might be put forward, that the Gulf stream weed "Sargassum bacciferum" is very poor in iodine. This, however, may be only negative evidence, as there may be richer varieties nourished in the same waters, and the "gulf weed" may be destitute of iodine for somewhat similar reasons to those which prevent the black weed and the reeshagh of Yar-Connaught from secreting it.

If the iodine is brought over by the Gulf stream, naturally it might be expected that it should be best developed near the source, and in places farther removed it ought to be less and less, according to distances; this however does not seem to be the case, for Mr. Steven says, "Iodine although very sparingly developed in sea-water is very generally distributed, and the iodine producing fuci, wherever found, in Ireland, England, Scotland, Channel Islands, France, or Japan, are nearly uniform in composition. In 1857 I analysed some specimens of L. digitata vera and L. digitata stenophylla from Iceland. They were identical in every respect with those found at home; quite as rich in iodine as the best Irish." In none of the published analyses of sea-water that I can find, is the quantity of iodine recorded, it being always mentioned as "a trace." To settle the question whether the Gulf stream is the carrier of it to these shores, it seems necessary that a series of analyses should be made, especially of the waters of the Gulf stream, in all of which the quantity of iodine should be carefully determined. In some medical books there is the vague statement, "A cubic foot of sea-water contains ·005 grain of iodine," but as no authority is given, much reliance cannot be placed on its value.[†]

[*] See 'Manual of Mineralogy,' by J. D. Dana, M.A., &c., &c.; and 'Glossary of Mineralogy,' by H. W. Bristow, F.R.S., &c., &c.

[†] In the *Journal des Connaissances Médicales* (published in November last), there is a brief notice of a method proposed by M. Moride whereby to prepare tinctures from the iodine producing sea-weeds for medicinal purposes. In it are first mentioned the iodine and non-iodine producing weeds, and then the writer goes on to state:—"Sea-weeds containing more chlorine and potash than soda are richer in iodine than in bromine, and the contrary is the case if the plant contains more sulphuric acid and soda than potash." Guided by these general facts, M. Moride conceived the idea of turning these plants to account in their natural state, that is, without subjecting them to a combustion which may modify them considerably, and drive off their most useful volatile ingredients. M. Boussingault and M. Humboldt had stated that in America the inhabitants of the Cordilleras of the Andes were in the habit of using the decoctions of sea-weeds, or else their alcoholic tinctures, in cases of scrofula, wens, and lymphatic tendencies. These liquids are,

In conclusion, it may not be out of place to give a very brief description of the coast, but more especially of those places at which the kelp manufacture is principally carried on. As before mentioned, Yar-Connaught on the west and south-west is indented by numerous fiords, bays, creeks, and cooses. This has led some people to imagine that the name of its western portion, Connemara, is derived from Coum-ne-mara, *i.e.* the "cooms or bays of the sea." This however is incorrect, for, according to the historian O'Fflahertie, the tract was called Conmac, after the name of its prince, and *ne-mara* (of the sea), to distinguish it from his other territories, also called after him, but situated in other counties, such as Conmac-ne-rein in the Co. Longford, Conmac-ne-culy in the Co. Mayo, &c., &c.

Bounding Connemara on the north, and separating it from the county of Mayo, is a remarkable fiord called The Killary, which is over nine miles long, sometimes a quarter, rarely half-a-mile wide, and embosomed in hills that rise abruptly from the water's edge to considerable heights, Moahlrea (the bald king), the highest, being 2688 feet in altitude. South-westward of The Killary, between it and Slyne Head, the south-west point of Yar-Connaught, are other bays, that extend nearly east and west, but none so considerable as The Killary; while eastward of Slyne Head the bays and creeks run north and south, or nearly so, and these latter, combined with east and west straits, form an archipelago between Kilkieran and Greatman's Bays.

Off the coast between the Killary and Slyne Head are numerous islands and sea-rocks, or, as they are locally called, illauns, carricks, and carrigeens, swept by the full force of the Atlantic, therefore most advantageous ground for the growth of the red weed; and on the islands, more especially Innishbofin, also on the main land, but particularly in the neighbourhood of Rinvyle, a considerable quantity of kelp is burned. Hereabouts would not be an unfavourable place for one interested in the manufacture of kelp to examine the process; for at Letterfrack (5 miles from Rinvyle) excellent accommodation can be had at Cassan's Hotel; or, if the observer would like to rough it a little, and see more of the natives, he can take a canoe from Cleggan Bay, and

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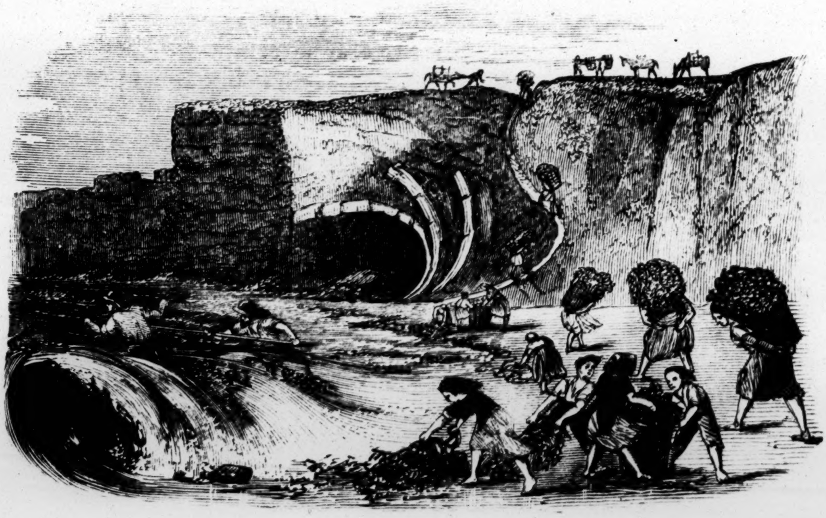
however, very unpalatable, and have, moreover, a strong smell of the original seaweed; to avoid which M. Moride proceeds as follows:—"The plants, gathered on the rocks on which they grow, are slightly rinsed in fresh water, in order to rid them of the salt water adhering to them, then dried and exposed to the sun, whereby they lose their smell and taste of wrack; after which they are pounded in a mortar and macerated in strongly alcoholized water at a somewhat high temperature. The iodized tincture thus obtained may be used to prepare a medicinal wine or else a syrup with, which will be found useful in all affections for which iodine is prescribed."

run over to Innishbofin, to remain there until driven off by the kelp smoke. This smoke is very peculiar; it does not ascend like other smoke, but hangs near the surface, creeping along the ground, and lying in heavy clouds in the cooms and hollows among the hills. The natives consider it very wholesome; but strangers generally find it heavy and oppressive, and usually contract a headache from its smell. Visitors might also stop at Mullarky's Hotel in Clifden, from whence they could see the kelp burning to the northward and southward, but the nearest station to the great kelp *dépôts* is the village of Roundstone.

Roundstone, instead of being a miserable village, ought to be one of the principal ports on the west of Ireland, having an excellent harbour, easy of access and sheltered from all winds; moreover, opening into it, are other land-locked harbours, such as Blackhaven, Bertraghbwe Bay, Cashel Harbour, &c. It may be truly said of it, that "it is favoured by God but neglected by man;" and this in a great measure seems due to an absentee proprietary. From this village the kelp fires can be seen on all sides,—out on the islands, in on the bays, north, south, east, and west; and unless there is a good breeze, the horizon will be formed of a heavy cloud of brownish-grey smoke. The great kelp stores are on Kilkieran and Cashel Bays; at the former there is a good pier, alongside which the kelp ships can go; but in Cashel they have to lie out, and the cargo is put on board by boats loaded by girls who carry the blocks of kelp from the store on their backs (see vignette, p. 341), and this exercise so develops them, that they have chests like dray-horses; moreover, it is wonderful what a weight they can carry; some of them thinking nothing of a block two or three hundred-weight.

Roundstone is also a favourable locality from which to visit and explore the beds and tracts of seaweed, the most favourable time being during calm weather and spring tides. The village should be left in the morning with the tide; taking a course eastward or westward as the wind suits; as the tide falls (if the weather is set fair) so will the wind, and by low water the boat ought to be lazily drifting about on a sheet as smooth as a mirror and almost perfectly transparent, so much so that objects, in from twenty to thirty fathoms of water, are quite apparent. Then if an observer leans over the gunwale of his boat he will see the submarine gardens in all their pristine grandeur. If in the deeps of the land-locked bays, there will be groves of the Laminaria bulbosa; or perhaps he may drift in among the cord-like fronds of the Chorda filum, or among the "sea thongs" or Himanthalia lorea. Outside, in the open sea, or, even in the vicinity of the islands, if there are facilities for a strong tide, will be seen groves of the Laminaria digitata tangled up with parasite sea-weeds, or perhaps a mass of the beautiful Alaria esculenta fringing precipitous rocks. However, one of the most characteristic sights is a low rock in a sandy waste, on which is a garden of L. saccharina or L. phyllitis with their accompanying green, purple, and red parasitic weeds, and in and out through the foliage may be seen little fishes, crustacea and mollusca, creeping, gliding, and sporting.

To the eastward of the previously mentioned archipelago the coast line extends in an east and west direction to Galway town; while on the southward, at the entrance of Galway Bay, lie the Aran Islands. These latter, with a fair breeze, are not more than two or three hours' sail from Roundstone, and are well worthy of a visit, not only on account of the quantity of kelp there manufactured, but also for their peculiar formation, the outcrop of the strata forming long continuous large steps or terraces, and also for the richness of their flora. Besides these natural attractions, anyone interested in archæology will find a good field among the Christian and Prehistoric ruins that exist on all the islands, but more especially on Innishmore.



II. THE LAMBETH OBSERVATORY.

By Robert James Mann, M.D., F.R.A.S.

In the outer courtyard of the Government India Store, situated in the Belvedere Road, Lambeth, and on the bank of the Thames, on the direct line of river-side thoroughfare between the Waterloo and Westminster Bridges, there stands a very complete and pretty little observatory devoted to severe philosophic work, which would certainly not be looked for by the uninitiated in this locality and in these surroundings. The establishment is of modern date, and but little known. Its history, and the reason for its occupying this site, are, however, simple and plain. It rose to its present position when the Indian Store disappeared from the old and traditional ground of Leadenhall Street, and when the Indian administration took westward wing to find its new and more convenient home in Downing Street. At that time it was thought meet to provide a lodgment for the store department nearer to head-quarters, and a very commodious building was accordingly erected in the Belvedere Road, and opened in the month of February, 1864. The general purpose of this building is to furnish a temporary warehouse in which all articles destined for the military, medical, and educational branches of the Indian service may be received, examined, and packed for shipment.

A considerable number of scientific instruments of various classes have for some time been annually sent out for use in India under the auspices of the Indian Government. In the old days of the Indian administration, the custom in regard to such instruments was that a sealed pattern of each kind of instrument in occasional demand was kept in the store department attached to the establishment in Leadenhall Street, and whenever a supply was required for service in India, the instrument makers of England were invited to send tenders of the prices at which they would undertake to furnish the required articles, constructed in exact imitation of the sealed patterns. In general practice, the maker who offered *to supply at the lowest price* received the commission; and when it was executed the instruments were sent in to the store, superficially compared with the pattern to see that they were of the kind that had been ordered, and were then shipped off to India, and the transaction was held to be complete.

In this proceeding the real excellence of the instrument, its real fitness for the satisfactory performance of the work it was designed to accomplish, was altogether left to the accident of the way in which the maker might be able or willing to perform his share of the bargain. It was assumed that if the implements looked like the pattern, it would be all that could be desired, and if by any accident it was discovered that it was not all that was desired, the responsibility was conceived to rest upon the shoulders of the tradesman who had thus badly executed his order. This system was obviously not likely to prove satisfactory where the delicate and exact work of observational science was concerned. In the first place, the sealed pattern assumed a perfection in instrumental construction which will not be obtained after many more centuries have been consumed in unceasing improvement; and in a sense also ordained that Indian science should operate with obsolete instruments, instead of with the best that could be produced in the existing state of cosntructive art. And in the next place, the best makers who had a reputation for excellence to sustain were more or less excluded from the Indian orders because they were expected to compete with men who looked to profit out of low prices, rather than to furnish excellence of work.

It happened while matters were in this position that Colonel Strange, who was the originator, and is now the life and manager of the Indian Store Observatory, was requested to examine a quantity of instruments that had been sent to England for repair, before they were again shipped off for India. In performing this duty, he was constrained to urge that the greater part of these instruments, about which a considerable expenditure had been incurred, were really of an obsolete form and useless for practical work; and to recommend that the whole should be sold for anything that could be made of them, rather than that the serious injury should be inflicted on officers in India of giving them tools that could only furnish erroneous and misleading observations.

The instruments accordingly were withdrawn from the service, and the incident had also a further and more practical result. It opened the eyes of the authorities to the need of a different mode of procedure, and arrangements were forthwith entered upon to secure at least a standard measure of excellence in all instruments sent out to India. At first Colonel Strange was commissioned to examine batches of instruments of various kinds fitfully, as they were prepared for shipment; but after he had pointed out that this could only be serviceable when means of efficient examination were available, he was requested to submit a recommendation as to the appliances which were requisite for the scrutiny. The recommendation was that a fixed observatory should be established for the work, and a plan of the character and instrumental furniture of this testing observatory was suggested. The plan was formally and officially examined by the Astronomer Royal, the President of the Royal Society, and the Director of the Ordnance

Survey; and these practical authorities pronounced that the proposal was sound in principle, and likely to be efficient in operation. The order was then issued that the observatory should be constructed; and the construction, and subsequent management of the establishment, were placed in the hands of the designer, Colonel Strange, who in addition to a natural taste for, and capabilities of, dealing with delicate and fine mechanism, had enjoyed the field experience of thirteen years of service upon the great trigonometrical survey of India.

The first matter that had to be decided in connection with this design was the place where the fixed observatory could be planted. Up to this time all instrumental examinations had been made in the old building that had been used as the Indian store, and that stood opposite to the ancient Company's "House" in Leadenhall Street. It therefore was deemed only natural that the instruments should follow the store, and that the observatory should be planted on the ground acquired by the department in Lambeth; the site was obviously not the best in the world for the purpose, but as no other available position could on the instant be fixed upon, it was ultimately resolved to do the best that could be done in connection with the Lambeth store, and the existing observatory was commenced in the year 1865.

The earliest proceeding was necessarily to neutralize the natural unfitness of the ground and position for exact instrumental work, so far as this could be done. This has been most admirably and most efficiently accomplished, and as follows:—First, twelve iron screw-shod piles with the widest part of the spiral thread 2 feet in diameter were wormed into the gravel, which here lies 24 feet below the surface of the ground. Broad heads of cast iron were next keyed upon the top of the piles. Thick slabs of flag-stone were then laid upon the pile-heads, and the space beneath filled in with concrete cement to the depth of about three feet. A circular platform of brickwork was finally constructed upon the flag-stones, and upon this, two semicircular segments of wall were reared round the circumference, and a solid pedestal of masonry was erected in the centre. This circle of wall, cut by two gaps at opposite points of the circle, and this enclosed central pedestal are the objects which now form the visible base of the observatory, and which carry the chief instruments employed in the scrutiny. A wooden platform, or floor, between the circular wall and the central pillar, to which access is obtained through the gaps, is carried upon beams that are supported from beyond the system of pile-work, and is carefully isolated from all mechanical connection with the piled foundation, so that the observer moves about upon this floor without effecting any disturbance in the position of the instruments carried upon the walls and the pedestal. This method of securing a firm foundation upon so unpromising a base as a river-bank shaken by the incessant rolling of heavy carts, has been found to be very efficient, if not practically perfect. Since the first setting of the masonry of the platform not the slighest permanent change has occurred in the bearings of the instruments. Passing carts communicate a slight transient vibration for the moment, which, however, has no other inconvenience than causing an occasional brief suspension of observation.

Upon entering this little model testing observatory of the Indian store, then, the general aspect is that of a square room with a raised circular platform in its centre, reached by a small flight of stairs. A broad solid wall-like rim, breast high, and included within an outer suspended pathway for the observer, runs round the platform, and affords a convenient resting-place for instrumental appliances of various kinds. In the midst of this circle a flat-topped pillar forms the bed upon which the instrument to be tried is placed by the examiner.

Overhead the broad glass roof, with the uninterrupted space of clear sky, indicates that the star-rulers of the night can be appealed to whenever such higher and more refined arbitration is deemed desirable.

One of the most important objects that is attempted in this observatory is the examination of the exactness of graduated circles that are designed for horizontal measurement. Unless these circles do measure equal and true degrees in all their parts, it is obvious that the angular intervals recorded from them are not worth the paper upon which the records are inscribed. To accomplish this end four horizontal tubes, called collimators, have been placed on different parts of the circular wall, so that an observer can contemplate each of them from the telescope attached to the instrument under trial. These collimators are in reality only so many fixed and immovable points, occupying for the time known, or more properly ascertainable, positions on the great wall-circle, and therefore including also known, or ascertainable, angular intervals between them. The exact reference-points, or virtual centres in these collimator tubes—"the marks to be collimated or aimed at"—are of a varied character. In one there is a system of diagonally crossing spider-threads, and in another of horizontally and vertically crossing threads, forming the reference-points by their intersection. In yet another tube an artificially fixed star is formed by throwing gaslight through an exquisitely minute aperture, which has its own image reproduced in the focus of a convex lens, so contrived as to fall only one-fifth of an inch from the curved surface of the glass, a proceeding which practically reduces the image of the simulated star to the very smallest dimension to which it is possible to compress it. The four reference-points, or collimators, are, for convenience sake, so placed upon the wall that the angular intervals included between them on the circular arc are respectively 30, 60, 120, and 150 degrees. This arrangement, by varying the pairs of collimators used, allows twelve different angles to be tested. The test, in plain language, is simply reading these angles off as they are given by the circles of the instruments, and then shifting round the circles again and again, so that exactly the same work is performed in succession by different portions of the same graduated rim. If the graduations of the circle are correct and trustworthy, the angles read off between any given pair of collimators will obviously always have the same value whatever portion of the circle be employed in the reading. This test is a very accurate and a very severe one. The slightest inexactness and failure in the mechanical work at once becomes glaringly obvious, and can be estimated as a question of amount as well as of fact. In practice the process is repeated with each instrument on successive occasions, to test permanence as well as exactness of construction and performance;—to see that there are no weak and yielding points, or shifting screws, or attachments, involved in the structure. If the reference-points were simply so many fixed spots, established upon the circular wall, it would be necessary that every graduated circle placed under examination should be truly centred upon one point with the most refined exactness. This necessity is practically avoided by placing the reference-points in tubes behind, or beyond, curved lenses of glass, which have the useful property of always sending parallel rays to the telescope of the tried instrument, and therefore always securing the invariability of each angular instrument however the centre of the reading circle may lie. Colonel Strange has satisfied himself by actual trial that the centre of a graduated circle, or arc, may be shifted a fifth of an inch without making any appreciable alteration in the value of the angles read. It is this especial virtue which converts a mere visible fixed point of reference into what is technically known as the "collimator."

The testing of *vertical* circles is a far more difficult piece of business than the trial of horizontal ones, for this reason—in vertical circles the telescope which is employed in making each observation is rigidly connected with some unalterable radius of the circle, and any given angle included between reference-points cannot therefore be applied over and over again to different portions of the circle. This however is not of very much moment, because the vertical and horizontal circles of any given maker are turned out by the same graduating instrument, and if the horizontal circle is found to be graduated correctly, the vertical circle may with some confidence be assumed to be of the same excellence. In the case of the larger and more important instruments the examination is rigidly carried out by observing standard Greenwich stars as they pass over the meridian. The angular intervals lying between the culminating points of these standard stars are most accurately determined by multiplied observations at established observatories; therefore all that is necessary, is to see that the graduations of the circles indicate the precise angular intervals that they ought to show for the stars that are employed in the test. There is, however, one appendage to all vertical circles that is of a somewhat slippery and suspicious character, but that is nevertheless at the bottom of all correct indication, and must therefore be made the subject of scrutiny. This is the level which is used to give the horizontal point from which vertical elevation is reckoned. One portion of the internal surface of the glass tube used in the construction of the level is so ground that it just departs from a straight direction in the line of length, so far as to give the air-bubble imprisoned on the spirit an inclination to rest in the centre. But this surface requires to be graduated so that the bubble travels over exactly the same linear space on the graduation, for every equal angular change in the elevation of one of the ends of the tube. To ascertain whether the level is so made that this actually occurs, it is placed upon a cradle of iron, and a delicate screw with a divided head is turned hundredths of parts of a revolution at a time to raise or depress one end of the cradle. If the level is well made, the bubble travels one mark of the graduation for every hundredth part of a turn of each thread of the screw. This appliance of test is so delicate, that if the finger and thumb are placed gently against opposite sides of the bearer, the bubble moves from its place under the expansion caused by the mere warmth of the living contact; or if, again, the hand be pressed firmly on the two-inch-thick slab of slate that carries the instrument, the flexure of the seemingly inflexible slate is immediately made apparent by the travelling of the bubble.

The optical performance of the telescopes of small surveying instruments is tried by fixing a card, which has a series of lines clearly traced upon it, some the fiftieth, some the seventy-fifth, and some the hundredth of an inch asunder, 25 feet away; telescopes of different degrees of power should render the divisions of the one or other of these series distinctly visible at this distance. The lines which are the hundredth of an inch asunder subtend seven seconds of angular measure at the distance of 25 feet; that is to say, a telescope which can show the closest lines as distinct visible objects at the distance of 25 feet, will be capable of clearly discerning an actual object of even less than seven seconds of size. The card containing the tracing of these lines also carries the exact representation of the scale of the surveyor's levelling staff as it would be seen at a distance of five chains and ten chains. These scales are produced in most exquisite clearness and perfection by photography. They are printed from a standard negative plate preserved in the observatory, so that identically the same test can be supplied in any number of instances where instrument makers may wish to avail themselves of it.

There are two clocks in the observatory, of which one marks mean, and the other sidereal time. The mean time clock is in immediate and sympathetic connection with the great central time standard of the Greenwich Observatory, the communication being effected by electrical agency. The bob of the clock-pendulum is a hollow coil of copper wire, embracing, without contact, a selection of permanent magnets. The ends of the coil pass away, and are ultimately connected with the Greenwich clock, which supplies through the wire a current of electricity at every alternate second. The movement of the clock-train is maintained in the usual way by a weight; but the accuracy of the going is secured by the magnetic contrivance. Every alternate second of true mean time, the swinging magnet receives a slight accelerating pull from the coil, virtually converted into a magnet itself for the instant. A tell-tale magnetized needle marks the seconds by alternate sway, but always stands still at the first second of every hour by the Greenwich time, and starts its vibration again at the fourth second after the hour. This most elegant and efficient application of electro-magnetism is due to the ingenuity of Mr. Jones, station-master at Chester, and is known as "Jones's Patent Controlled Pendulum."

Meteorological instruments, in every variety, are tested at this observatory; the standard barometer has been carefully compared with the standards of both Kew and Greenwich. The divisions of the scale are also very accurately compared with a measure of length finely marked into hundredths of an inch, taken primarily from the preserved national standard. Aneroids are tried by a very ingenious contrivance. A batch of the instruments is placed in a glass-covered cylindrical reservoir, which is connected with the receiver of an air-pump, in such a way that the channel of communication is crossed by a diaphragm of porous porcelain. The receiver of the air-pump is then exhausted to a certain degree, and the exhaustion of the reservoir containing the aneroids goes on through the porous diaphragm very slowly, in order to imitate the action of the instrument when used to measure mountain ascents. The exhaustion takes place at the rate of about one inch of pressure per hour, and at every half-inch of change the instrument is compared with an accurate mercurial barometer forming part of the apparatus.

Thermometers are proved in the freezing and boiling points by immersion in melting ice and in steam; and a certain number of intermediate points of temperature are also verified, by comparison in water, with standards authenticated at Greenwich and Kew. With the existing appliances this comparison is carried, not without difficulty, up to 92 degrees of Fahrenheit. It is deemed most desirable, where service in India is contemplated, nevertheless to extend the examination of intermediate points up to 120 degrees. But this is a very delicate and difficult task. Whenever there is more than 30 degrees between the natural temperature of the air and the temperature of the water in which the instruments are immersed, the cooling of the water goes on so rapidly and so irregularly that instruments immersed in the liquid are really differently affected in different places. A remedy for this imperfection is under consideration, and it is intended that means shall be provided, as opportunity allows, for testing large numbers of thermometers at a time in which the uniform diffusion of temperatures quite up to 120 degrees is artificially provided for in a vessel surrounded by a large body of heated and constantly moving water, the heat of which is to be retained by a jacket, or coating, of very slowly conducting material. The freezing points of four standard thermometers, which, after all, are the sole reliable and unalterable elements, are examined once a-year to guard against error from the contraction of the bulbs and other slow changes of constituent material.

The instrument which occupies the place of scrutiny in this testing observatory at the present time is one of a very magnificent set that has been for some time preparing for use at the central stations of the great Trigonometrical Survey of India. It is a large theodolite (one of a pair), with a three feet vertical, and a two feet horizontal, circle. Its companions for this service, of which specimens stand in reserve in other parts of the observatory, are a pair of transit instruments, a pair of zenith sectors, and a pair of chronographs. In many particulars these noble instruments are entirely unique, and deserve a much more precise and particular description than can here be given, in consequence of limitation of space.

It may, however, be nevertheless briefly explained in regard to them, that each theodolite, which is designed mainly for determining the angles of large triangles through the instrumentality of heliotrope flashes given by mirrors from twelve to forty miles away, has a frame chiefly composed of aluminium bronze, which is three times as rigid as a similar structure of gun-metal, and therefore confers twice the rigidity, in two-thirds of the weight that gun-metal can furnish. The large circle bearing the graduations for fine work is protected by an outer guard-ring which takes all the strain, and serves also to equalize temperature. The tangent screw is made, by the application of a peculiar spring, to exert an invariable force. The adjusting levels are of great delicacy, and the telescope is furnished with two eye-pieces, one with a horizontal and the other with a vertical set of micrometers. The foot screws press against flat arms of metal, which are a fixed and integral part of the stand, to obviate lateral *wriggle*.

The transit instrument, which will fix the longitude of the principal stations, has an adjustment for the bearings of the pivots, because the plan, now universally adopted in large instruments for fixed observatories, of banishing entirely these adjustments, could not be conveniently adopted in peripatetic instruments, that must be moved from station to station. Each pivot is carried on a triangle of iron resting on three screws, furnishing means of rough adjustment for horizontality. The connection of the pivot with the triangle is, however, managed through a kind of ball and socket intervention, in which the socket or cup is attached to the triangle, while the broad convex spherical surface representing the ball is the bottom of the metallic piece which supports the cylindrical bearing of the pivot. One pivot allows of vertical, and the other of horizontal adjustment; in both cases the ball and socket adapting itself with ease and exactness to the movement effected. Four levels for securing horizontality, *hang from spindles mounted transversely upon the centre-piece of the telescope* itself, and in such a way as to remain in free and constant adjustment during the rotation of the telescope upon its transverse axis.

The chronographs, or time-registers, prepared to make the transit observations to be recorded upon paper by electrical agency, are chiefly remarkable for a most exquisite contrivance for securing uniformity and exactness of movement, which is the invention of M. Foucault, of the Imperial Observatory of Paris. A barrel is carried round every two minutes by a tram of clock-wheels, and two companion points so press upon paper stretched over the barrel, and saturated with an appropriate chemical agent, as to allow a deep purple dot to be impressed on the paper every time the pendulum of a clock sends a momentary current of electricity through one point, which in practice is at the completion of each second, while the finger of the observer does the same thing at will with the other point, to register the time of the observation, so interpolated between the seconds-dots. The movement of the barrel is regulated to rate and uniformity—first, by a fly-wheel, something like a miniature paddle-wheel, which revolves rapidly in a hollow case furnished with a peripheral slit, which can be enlarged or diminished, to secure more or less aërial resistance, as it may be desired. But in addition to this, the double balls of the ordinary Watts' steam-governor are attached in such a way that when they diverge from each other with too rapid motion, they lift the weight of a lever-mounted counterpoise by rods coming down from the middle of the diverging arms. The more rapidly the balls revolve the more load they take upon themselves from the lever-weight as a retarding influence. The weight of the lever hangs, for this purpose, perpendicularly under a suspending pivot, and therefore in repose and out of use, when the gyration of the governor is not too fast and the drag is not wanted. It only comes into effective operation when it is drawn out sideways by the too rapidly revolving governor acting upon a tail-like lever arm above.

The zenith sector, which is to give the latitude of the principal stations, is of the same optical and measuring power as the zenith sector of the Royal Observatory, but on account of its peculiar construction, weighs only 595⅛ lbs., while the Greenwich sector weighs 1140 lbs. It consists essentially of a vertical pillar, carrying a transverse axis, which has, in place of a wheel, two crossing sets of radii, of which one pair is in reality the telescope, and the other pair the arm of the sectors, read by four microscopes, and each including an arc of 45 degrees. The sectors are free from all mechanical strain, and only *looked at* by the microscopes. In observing, the position of a star nearly on the meridian and within 15 degrees of the zenith is noted, and the graduations of the sectors are read off. The instrument is then turned half round on its vertical axis, the star brought into the telescope field again, and the sectors once more read off. The angular interval of the arc comprised between the two readings is then necessarily twice the zenith distance of the star; and if the star is a standard star with known and determined polar distance, this at once becomes an indication of the latitude of the place whence the star is observed. The zenith distance of the star gives the height of the pole of the heavens from the horizon, and this involves the angular distance of the place from the earth's pole; or, in other words, its latitude. The star is referred to its exact place on the meridian, as it has to be observed in succession immediately before and immediately after its culmination to allow for the reversal of the instrument, by a micrometer wire adjusted in the field of vision. A series of very beautiful and perfect mechanical expedients are adopted to combine in this instrument the two opposite excellences of lightness and firmness; in other words, to enable the instrument to be readily transported from station to station, and yet to make it of high astronomical value when in use. The entire series of these instruments has been in hand and under examination during seven years, and within that period they have undergone continual and frequent modifications under the suggestions of the tests applied, and are therefore in a fair way of presenting in the end a measure of excellence which could not have been attained without the exact and refined appliances of scrutiny which the establishment of this observatory affords. Indeed, no better witnesses than these instruments could be called in support of the argument urged by Colonel

Strange, at the last session of the British Association for the Advancement of Science, for the institution of increased facilities for prosecuting research into the physical conditions and laws of material nature, and for improving man's dealings with those mighty, though subtle powers.

One hundred different kinds of instruments are tested in this useful and unpretending little observatory at Lambeth, and the number of individual instruments examined each year now amounts to about four thousand. The final result of the establishment of the observatory has, in Colonel Strange's opinion, amply justified the proceeding and established its need. The Colonel, to use his own words in speaking of the matter, considers that "the instruments now sent out for use in India are to their predecessors very much what the civilized man is to the rude savage." The practice in connection with the testing observatory is that orders for the different kinds of instruments required are given to the best makers at prices which enable the highest amount of mechanical excellence to be furnished, and which justify the exaction of the best possible workmanship. No trammels of "patterns" are incurred, and the freest scope is left for the adoption of rapidly progressing improvement in mechanical art. The maker who receives the commission goes to the observatory to ascertain exactly what is required of him. This often leads to a lengthened discussion, and extended deliberation before the work is commenced. The price is estimated by anticipation, and submitted to the inspector, and if in his opinion the estimate is reasonable the work is proceeded with. The instrument on completion is sent to the observatory on the understanding that the right of rejection has been reserved either provisionally or unconditionally, and that in either case any such decision is to be held final. Responsibility for excellence of work is thus transferred from a necessarily interested maker to an independent and specially qualified judge. Makers are continually invited to avail themselves of the exceptionally excellent facilities of the observatory in testing their own work, and are so incited to renewed efforts to obviate imperfections. In this way the most sagacious and capable of the profession come to see at a glance that their performance is made the object of examination by an impartial tribunal that only concerns itself with facts, and has nothing to do with hesitating and loose opinion, and that therefore the Lambeth Observatory constitutes a court of final appeal whose decisions must be held to be beyond further question or dispute.

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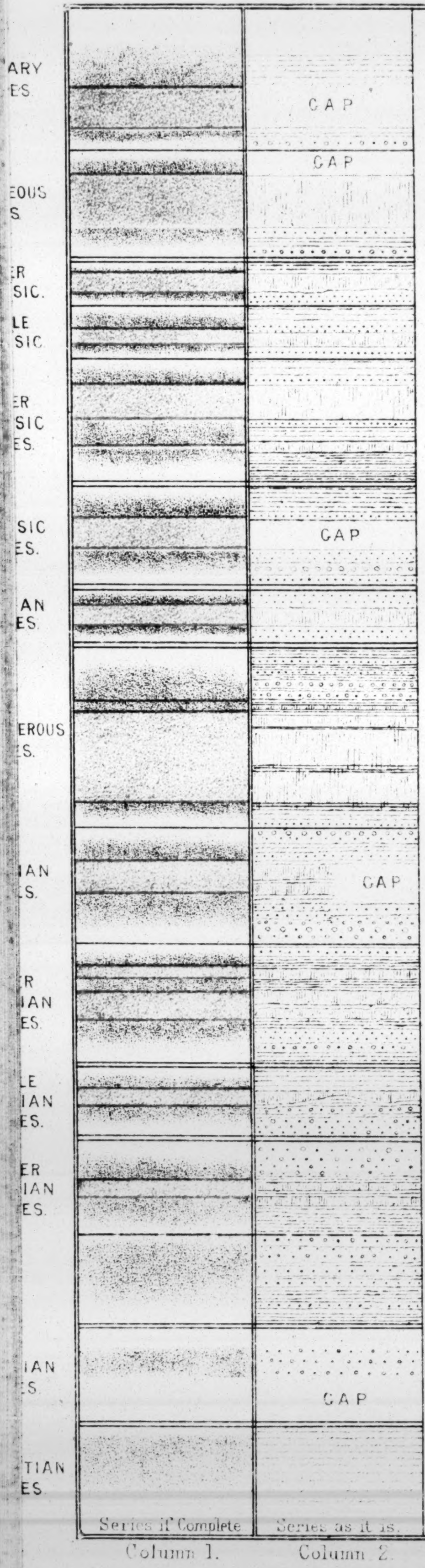

3. *Dark Slates, Sandstone, &c. of the Alps. (Glarus).*

2. *(Nummulite Limestone, not represented in Britain).*

1. *Thanet Sands, Reading Beds & London Clay: Sands, Gravels &*

3. *(Upper sedimentary member lost by denudation).*

2. *Upper & Lower Chalk, and Chalk Marl &c.*

1. *Green Sand & Gault .. (Sands, Gravels & Clays).*

3. *Marine representatives of the Purbec & Wealden Beds. (Middle Purbec*

2. *Portland Limestone.*

1. *Portland Sands.*

3. *Kimmeridge Clay & Upper Calc. Grit, (Sandstone).*

2. *Coral Rag. (Limestone).*

1. *Lower Calc. Grit. (Sandstone).*

3. *Oxford Clay & Kelloway Rock.*

2. *Bath and Inferior Oolite.*

1. *Lower, Middle and Upper Lias.*

3. *Rhætic Beds, Red Marl & Lower Keuper Sandstone.*

2. *(St. Cassian & Muschelkalk Limestones not represented. En being unsubmerged at this stage).*

1. *New Red Sandstone.*

3. *Upper Permian Marls. (St. Bees Sandstone?).*

2. *Magnesian Limestone.*

1. *Lower Permian Sandstone. Sandstones, Marls & Conglomerat*

3. *Coal Measures, Millstone Grit & Yoredale Series.*

2. *Carboniferous Limestone (with Shales & Sandstones in the No*

1. *Lower Limestone Shale. Carboniferous Slate. (Upper Old Red Sand of Scotland).*

3. *Shists & Sandstones* — *Devon* — 3. *Middle Old Red Sandstone.*

2. *Ilfracombe Limestone Series.* — *Devon* — 2. *(Gap)*

1. *Lynton Slates & Grits.* — *Devon* — 1. *Lower Old Red Sandstone.*

3. *Upper Ludlow Rock & Tilestones.*

2. *Aymestry and Wenlock Limestone Series.*

1. *Denbighshire Grits, Flags & Slates.*

3. *Tarannon Shale.*

2. *Llandovery Limestone.*

1. *Upper Llandovery Rocks.*

3. *Lower Llandovery Rocks & Caradoc Sandstone.*

2. *Bala and Llandeilo Limestone Series.*

1. *Tremadoc Slates.*

1. *1. 2. 3. Lingula Flags. (Forming a sub-group with a Calcareous central member in Bohemia).*

Cambrian Rocks. (Slates, Grits & Conglomerates). (Only partially represented in Britain).

Laurentian Gneiss. (Series only partially represented).

Malby & Sons Li

TENTATIVE CLASSIFICATION OF BRITISH ROCKS;

III. ON A TERNARY GEOLOGICAL CLASSIFICATION.

By Edward Hull, M.A., F.R.S.

The views I am about to advance in the following paper are the result of observation and reflection extending over several years, at first somewhat vague, but now taking a definite form and direction. They are advanced with some diffidence, and I am aware that exception will be taken to some of my conclusions as being contrary to general acceptation. Such objections, as far as they have occurred to myself, have been well weighed. It must be left to time to determine whether there is sufficient ground for believing in a general law of development of geological formations, depending on the mutual relations of organic and inorganic agencies; in the meanwhile I content myself with the endeavour to point out the evidences of such a law as bearing more especially on the arrangement of the British strata, leaving to a possible future the attempt to deal with those of foreign countries.

The tendency of several groups of strata to assume a threefold arrangement has not escaped the notice of geologists. Sir Roderick Murchison has very strongly insisted on it in reference to the "Permian system," both in Britain and the Continent. The Trias is (as its name denotes) an evident example, as is also the great Carboniferous series both of Britain and America. In each of these cases we have a central calcareous member interposed between an upper and lower member composed of sandy or muddy materials, to which the term "sedimentary" may be applied. Now, when we find in the case of three great groups following each other in order of time, and lying on the margins of the grand divisional line which marks the boundary of the Palæozoic and Mesozoic series, a similar order of sequence and of mineral composition, we may well pause and inquire whether there must not be some great principle lying below the surface, impelling or guiding the operations of nature in the direction of geological cycles, reproducing themselves at distant intervals, and indicated by the mineral characters of the rocks. It may seem a hazardous assertion that the history of a natural system (or group) of strata is analogous to that of a nation, or of man himself individually; that it has its beginning, its prime, and its decline; and that each of these stages has its representation. Yet the evidence in favour of this view is very strong, and seems to fall in with the course of physical events which we know to have occurred at successive geological periods. This view of the natural grouping of strata forced itself on my mind in 1862, when treating in the pages of the 'Journal of the Geological Society of London' on the relative distribution of the "calcareous" and "sedimentary" strata of the Carboniferous rocks of Britain.* I there remarked that "we cannot fail to have observed that many groups of strata have a tendency to arrange themselves into threefold divisions, the upper and lower being composed of sandstones and shales, the middle of limestone."

As the subject was foreign to the question before me at the time, except as bearing on the Carboniferous series, I did not pursue it; but in a paper more recently read before the Geological Society of Glasgow (in 1867), and published in their Transactions,† on another branch of the subject, I entered rather more fully into the discussion of this question, and ventured to state certain general principles as bearing on the operations of nature during past geological periods, which I venture to repeat here—

1st. *That in any formation composed of contemporaneous calcareous and sedimentary strata, these two classes of rocks must have had their sources in opposite centres or lines of distribution.*

2nd. *That in the same formation, consisting of calcareous and sedimentary materials, the maximum development of each class has been reached in positions relatively opposite to each other.*

In that paper I also proposed a threefold arrangement of the British formations from the Upper Silurian to the Tertiary inclusive. Since then I find that somewhat similar views have forced themselves on the mind of a distinguished geologist, Dr. Dawson, F.R.S., of Montreal, who, in his elaborate paper on "The Conditions of Distribution of Coal as illustrated by the Coal-formation of Nova Scotia," arranges the Carboniferous series of that country under three heads corresponding to those of Great Britain, and formed under similar physical conditions.

These alternations lead Dr. Dawson to the suggestion of "Geological Cycles" for the Palæozoic rocks of America, but he adopts a fourfold classification, though, as it seems to me, a threefold is a more natural one, at least as regards the Carboniferous group. The following is Dr. Dawson's quaternary classification, which he has more recently incorporated in his work, 'Acadian Geology:' ‡—

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* Vol. xviii., p. 134.

† Vol. iii., part 1.

‡ Although Dr. Dawson's paper was published more recently than my own already alluded to, it seems to have escaped his observation. This fact is satisfactory, as showing that on opposite sides of the Atlantic there is evidence of a natural order of arrangement according to geological cycles, and indicated by the mineral character of the strata. With regard, however, to the arrangement proposed by Dr. Dawson, it appears to me that a threefold classification might equally well be adopted, at least in the case of the Carboniferous series, and that there are no good grounds for dissevering the third and fourth stages. In the case of the other groups, it is a question for further inquiry whether the series is not also capable of arrangement according to a ternary system; but in order to determine this point, a fuller knowledge than I possess of the relative importance of the several members of the series, and their relations to each other over the whole area would be required.

TABULAR VIEW OF CYCLES IN THE PALÆOZOIC AGE IN EASTERN AMERICA.

CHARACTER OF GROUP.	LOWER SILURIAN.	UPPER SILURIAN.	DEVONIAN.	CARBONIFEROUS.
Shallow subsiding marine area.	Hudson-River group.	Lower Helderberg group.	Chemung group.	Upper Coal-formation.
Elevation followed by slow subsidences.	Utica shale.	Salina group.	Hamilton group.	Coal-measures.
Marine conditions; formation of limestones.	Trenton, Black-River, and Chazy limestones.	Niagara and Clinton limestones.	Coniferous limestones.	Lower Carboniferous limestone.
Subsidence; disturbances; deposition of coarse sediment.	Potsdam and Calciferous sandstones.	Oneida and Medina sandstones.	Oriskany sandstone.	Lower Coal-measures and conglomerates.

I now proceed to explain the principles upon which a threefold classification of strata with a calcareous central member is based; in order to which a knowledge of the origin of marine limestones is essential.

Marine Limestones.—And, first, this classification depends on the distinctive character of marine limestones as compared with all other stratified deposits. While conglomerates, sandstones, shales, and clays are essentially mechanical in their mode of formation, limestones (except under peculiar circumstances) are essentially organic. This, indeed, is the view of many of our most distinguished naturalists, and amongst others of our great authority on chemical geology, M. Bischof. This author states that the quantity of free carbonic acid gas contained in the sea is five times as much as is necessary to keep in a fluid state the quantity of carbonate of lime to be found in it. From this he draws the conclusion that it is impossible for any carbonate of lime to be precipitated in a solid form at the bottom of the sea by chemical action alone, and as the quantity is extremely small in the open sea, it is difficult to conceive that this can be effected otherwise than by vital agencies.*

This is a view, indeed, that can scarcely be questioned, and which is supported by reference to the composition of the limestones themselves. If, indeed, we might have looked for illustrations of this class of rocks as having been formed independently of organic agencies, it would have been amongst the most ancient formations of the globe. But what has been the case? Far down below the "Primordial zone"—in strata more ancient by at least two geologic cycles than those lately supposed to contain the first traces of animal life—we find a series of serpentinous limestones, of the real organic origin of which, the microscope has not left us in doubt. The researches of Sir William Logan and his colleagues of the Geological Survey of Canada, followed by other naturalists, have demonstrated that even the oldest known limestones on the surface of the globe owe their origin to the *Eozoon*, an animal considered by Dr. Dawson to be a Foraminifer.

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* 'Chemical Geology.'

It can scarcely be considered an argument against the organic origin of marine limestones, that they frequently exhibit no trace of organic structure. Limestones undergo metamorphism sometimes during their very formation in the open sea; how much more so after having been subjected to the action of heat, pressure, percolation of water, and other agencies, known and unknown, acting within the crust of the earth. On this subject the testimony of Mr. J. B. Jukes may be considered conclusive. Speaking of the rapid change which coral reefs undergo as observed by him during his voyage in H.M. ship 'Fly,' he says, "The surface of a reef when exposed at low water is composed of solid-looking stone, which is often capable of being split up and lifted into slabs bearing no small resemblance to some of our oldest limestones. These slabs, when split up, are frequently found to have a semicrystalline structure, by which the forms and the organic structure of the corals and shells are more or less obliterated."

As to the origin of the lime in the sea-water, that is a question immaterial to my present purpose, which is to show the essential distinction between the great group of calcareous formations in all geologic ages, and the strictly mechanical strata with which they are associated.* But before passing to the discussion regarding the relations of this latter class of strata, let us notice the several varieties of marine animals which have chiefly contributed to the formation of limestones, and which we may call "the limestone builders."

Limestone Builders.—At first sight it might be supposed that nearly all invertebrate marine animals having stony skeletons, or shells, contributed proportionally to the formation of limestones. But when we come to examine the classes of animals which in our own day have contributed to the formation of the calcareous ooze of the Atlantic, or the limestone reefs of the Pacific; and extending our researches back into geologic times, examine the structure of our great limestone masses, we soon perceive that the chief limestone builders have been animals of comparatively low organization, and embrace but a small portion of the sub-kingdom of *invertebrata.* They consist for the most part of the calcareous shells of *Foraminifera*, associated with the siliceous shields of *Polycystina,* forming not only the present calcareous ooze of the Atlantic bed but also a large proportion of the Secondary and Tertiary limestones. Next come the polyps or corals (*Actinozoa* or *Anthozoa*), ranging downwards from Palæozoic times to the present day, and entering largely into the composition of Silurian, Carboniferous, and Jurassic limestones. Then the *Bryozoa* or *Polyzoa*, largely distributed in the

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* The reader will find the question as to the origin of lime in the sea-water, and the *apparent* increase of calcareous rocks in more recent times, discussed in Lyell's 'Principles of Geology,' 10th edit., p. 608.

Carboniferous, Permian, and Jurassic limestones. With reference to this order I may here quote an observation of Professor Rupert Jones, who says,* "Some of the dark-grey Carboniferous limestone is as largely composed of *Fenestellæ*, &c., as the Permian limestone of Durham and Germany often is. One of the best instances of Polyzoan limestone (representing the Faxoe and Maestrich chalk) is the great white limestone of South Australia traversed by the Murray river, and which occurs again, as it were, in New Zealand as the Ototara limestone of Otago, &c."

The *Echinodermata*, as represented principally by the *Crinoideæ*, have contributed very largely to the formation of the limestones of the Carboniferous period, as well as, though in a smaller degree, of those of the Upper Silurian and Jurassic periods. As the late Professor Edward Forbes remarks, "Formerly they were amongst the most numerous of the ocean's inhabitants,—so numerous that the remains of the skeletons constitute great tracts of the dry land as it now appears. For miles and miles we may walk over the stony fragments of the Crinoideæ; fragments which were once built up in animated forms, encased in living flesh, and obeying the will of creatures amongst the loveliest of the inhabitants of the ocean."† The *Crustacea*, as represented by the diminutive *Entomostraca*, took a very important part in the formation of limestones, as abundantly proved by Prof. Rupert Jones and Dr. H. B. Holl.‡ In the "Caradoc Bala" limestone of the Chair of Kildare they largely occur, and, with other Palæozoic forms, are placed by these authors under the generic name of "*Primitiæ*."§ Prof. R. Jones states, "The Caradoc Bala limestone of Kildare swarms with them; so does that of Keisley in Westmoreland; so do the Upper Silurian limestones (Wenlock chiefly) near Malvern, as shown by Dr. Holl; so does the Upper Silurian limestone of Gothland remarkably. The Dudley limestone is rich with *Beyrichiæ*; the Upper Silurian limestone of Beechy Island in the Arctic regions and the Lower Silurian limestones of Canada (in the Calciferous and Trenton groups) either abound with, or are made up of, them. In the Lower Helderberg group of the New York State (Upper Silurian) there is a *Leperditia* limestone, and in Russia and Oesel Isle, Leperditiæ make up at least one of the limestones."‖ Prof. R. Jones and Mr. J. W. Kirkby, together with Mr. John Young and other authors, have also shown that these little crustaceans abound in the calcareous beds of the lower Carboniferous series of Scotland.¶ The part in nature played by the Entomostraca seems to have been that of scavengers of animal matter.

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* In a letter to the author (1868).

† 'British Star-fishes,' p. 2.

‡ 'Annals and Mag. Nat. Hist.,' 1865-8.

§ "On Palæozoic Bivalved Entomostraca, &c.," ibid., July, 1868.

‖ Letter to the writer (1868).

¶ 'Trans. Geol. Society of Glasgow,' vol. ii., part 2, p. 213; ibid., p. 155.

Amongst the above generally minute organisms, the molluscs lived and flourished, often contributing to the building of the limestones; and amongst the most important class of mollusca in this respect were the *Brachiopoda*, placed by naturalists almost in the lowest rank of this sub-kingdom.

I shall close this branch of our subject by offering the following synopsis of the chief limestone builders of successive geologic periods in ascending order.

Laurentian.	Foraminifera (?). *Eozoon.*
Silurian and Devonian.	Corals (chiefly of the orders *Zoantharia tabulata*, and *Z. rugosa* of MM. Milne-Edwards and Haime), Crinoids, Brachiopods, and Entomostraca.
Carboniferous	Corals (*Zoantharia tabulata*, *Z. rugosa*, *Z. tabulosa*), Crinoids, Bryozoa, Brachiopods, and Entomostraca.
Permian	Corals (not abundant; *Zoantharia tabulata*, *Z. rugosa*), Bryozoa, Conchifera, Entomostraca.
Triassic	Bryozoa, Echinoderms, Conchifera.
Jurassic	Corals (*Zoantharia aporosa*), Bryozoa, Echinoderms, Molluscs largely.
Cretaceous	Amorphozoa, Foraminifera, Corals (*Zoantharia aporosa*, *Z. tabulata*, *Z. rugosa*) Echinoidæ, Bryozoa, Entomostraca, Brachiopods (Terebratulæ).
Tertiary	Foraminifera (Nummulites), Corals (*Zoantharia aporosa*, *Z. perforata*, *Z. tabulata*), Echinoderms (*Echinoidæ*, *Asteroidæ*), and Ophiuridæ.

We have now to turn to the discussion of those strata of mechanical origin which are associated with the limestones.

Sedimentary, or Inorganic, Strata.—In contrast with the calcareous rocks, not only as regards origin but in mode of distribution, we may include all those strata which are strictly mechanical, such as conglomerates, sandstones, shales, clays with their several varieties and combinations, whether metamorphic or otherwise. It is not necessary to enter into a description of the manner of formation of this class of strata, except to observe that from the more rapid subsidence of the coarser particles which are brought down into the ocean and distributed over its bed—truncated sheets of strata of this class will have a tendency to increase in thickness in the direction of the source, or sources, of sediment.

Now, the existence of sandy or muddy sediment in the waters of the sea is well known to be detrimental to the growth, and even vitality, of many of the delicate organisms which chiefly contribute to the formation of limestones. On this point the evidence of observers is conclusive as regards the present inhabitants of the sea, and we may feel sure this adverse influence of muddy sediment extended far back through all geologic times. Taking the Polyps as the chief limestone builders of the present period, we find them flourishing in mid-ocean, or in tracts removed from the influence of turgid waters. Thus Mr. Darwin, when describing the coral reefs and atolls of the Indian and Pacific Oceans, refers to them as being at an immense distance from any continent, and where the water is perfectly limpid.* Mr. Jukes describes the water surrounding the barrier reef off the coast of Australia as being quite clear;† and Dr. T. Wright, in his summary of the character and conditions of development of modern coral reefs, says,‡ "where the bottom is muddy, and the rivers pour fresh water in any great abundance into the sea, there the reef-building Polyps are absent."

The Foraminifera, a group of limestone builders, distinct from Polyps and Echinoderms, seem to have been most prolific in limpid waters. In our present seas we find them largely associated with the Polyps, as well as engaged in forming a deposit over the bed of the mid-Atlantic, which if converted into land would yield a limestone not dissimilar to chalk.§ In geologic times we find two very important and pure limestone formations—the chalk, and nummulite limestone of the Eocene period,—for the most part composed of the shells of these little animals.

That the Brachiopods and the Crinoids especially of past times flourished with greatest vigour in limpid seas, is perfectly clear from the mode of their occurrence in the rocks themselves. Not only are they most numerous as individuals in the beds of the less earthy limestones, but we frequently notice the species (or their representatives) becoming dwarfed in size, as well as fewer in numbers, when we pass from limestones into adjacent clayey strata. In the Carboniferous limestone of Derbyshire, where these animal remains are found in such marvellous profusion, the rock itself contains scarcely a band of shale through hundreds or even thousands of feet.

If, then, there existed this detrimental influence, exerted by mud or sand held in suspension, on the vital development of those marine animals which contributed to the formation of limestones, it follows, that during any special geologic period in which both classes of strata (calcareous and sedimentary) were being formed, the maximum development of each class must have been in directions opposite to each other. If, for instance, the sediment was being transported and deposited over the sea-bed by a current coming from the north, the contemporaneously formed limestone would *grow* with greatest rapidity, and attain its greatest proportions far out to sea to the southward, and beyond the region to which the sediment was carried, and of this phenomenon we have several examples over the British area, the most striking of which are furnished by the Carboniferous, Permian, and Lower Jurassic formations.

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* 'Naturalist's Voyage,' p. 468.

† Voyage of H.M. ship 'Fly.'

‡ 'On Coral Reefs, Past and Present,' Trans. Cotteswold Naturalists' Club, 1866.

§ See Dr. G. C. Wallich's "Account of the Deep-Sea Soundings," 'Quart. Journ. Science,' vol. i.

As I have on a former occasion treated this branch of the subject at length, it will only be necessary here briefly to refer to the illustrations afforded by two of these groups of strata.*

Carboniferous Series.—The calcareous central member, or Carboniferous limestone, attains in central England a development nowhere else reached in Britain. Its base is never exposed, although the beds are over many parts of Derbyshire thrown into highly inclined positions with numerous faults and flexures. Several sections measured with the utmost care by the geological surveyors combine to give a thickness of more than 4000 feet for this great calcareous formation in this part of the country, where it is also in composition remarkably free from the intermixture of shales, sandstones, or other sedimentary materials. It is in this district also that its organic origin is strikingly brought to light, for it abounds in corals, shells, and crinoidal remains. To the region of Derbyshire we may emphatically point as a former ocean-bed, where during the era of the Carboniferous limestone, a limpid sea offered full scope for the development of the marine animals which were the limestone builders of that geologic period.

If, from the Derbyshire district, we trace the range of the Carboniferous limestone northwards into Scotland, we find this formation gradually deteriorating both in quality and thickness. In North Lancashire, Cumberland, and Yorkshire, it has nowhere a thickness exceeding 2000 feet, frequently less; and, as shown by Professor Phillips, is split up into several distinct bands by the intercalation of beds of shale and sandstone with coal. This deterioration is still more strikingly exhibited when we pass into Scotland, for in the Carboniferous districts of Lanarkshire, Renfrewshire, and the Lothians, the formation is represented by several thousand feet vertical of sandstones and shales, with coal and ironstone, and a few beds of limestone only attaining a combined thickness of about 150 feet. Here, then, we have a clear illustration of the effects produced in the calcareous strata by the introduction of muddy or sandy sediment. The same waters which, being free from impurities in the region of central England, gave scope for the maximum development of the limestone, were charged with sand or clay towards the north, and in proportion as this was the case interfered with the growth of the limestone, and in the Scottish area well nigh prevented its formation.

Carboniferous Sedimentary Strata.—But not only did the antagonistic influence of the muddy waters pervade the Carboniferous area during the period of the central calcareous member, but it held sway and gained ground throughout the succeeding stages so as almost to annihilate the limestone builders during the periods of the millstone grit and coal-measures, or cause them to migrate into other regions of the ocean. But the point we have specially to deal with is the direction from which this sedimentary matter was drifted. Now, the very accurate measurements which the Carboniferous series enable us to obtain, point clearly to a northerly source, for in this direction the sedimentary strata tend to attain their greatest development, and this, be it observed, is the direction in which the calcareous strata tend to thin away and disappear. Thus if we take a series of vertical sections along a line from Leicestershire and Warwickshire into North Lancashire, we find the proportion of the Yoredale series, millstone grit, and coal-measures as follows:*—

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* See my paper, "On the Relative Distribution of the Carboniferous Strata of Great Britain," 'Journ. Geol. Soc. London,' vol. xviii., p. 127 (with map).

Leicestershire & Warwickshire.	N. Staffordshire.	S. Lancashire.	N. Lancashire.
Feet.	*Feet.*	*Feet.*	*Feet.*
2600	9000	12,130	18,700

Here, then, we see a steady augmentation in the thickness of the sedimentary materials within a distance of about 120 miles to the extent of 16,000 feet.† In Scotland and the north of England, it is true, owing to a shallower sea bed, and the nearer approach to the parent land, the increase is not maintained, but the northern source of the sedimentary materials is no less clear.

Now, if it be inquired, "What relationship as regards the mutual development of the calcareous and sedimentary materials can there be between the period of the Carboniferous limestone and that of the succeeding strata?" the reply is this: *that these relations were maintained, though in different proportions, throughout all the stages of a natural group of strata representing a geological cycle (such as the Carboniferous), and were only reversed or considerably changed with the introduction of a new natural group.*

Permian Series.—My illustration from this group of the English strata will be stated in briefer terms than the foregoing.

The central calcareous member of this group is clearly represented by the magnesian limestone of Durham, and Yorkshire and Nottinghamshire along the north-east of England. Along this region it attains a maximum thickness of about 600 feet, as shown by Professor Sedgwick; while the overlying sedimentary strata are but feebly represented, and the lower red sandstone (*Rothe-todte-liegende*) does not exceed 250 feet in thickness. Now, if we compare this section with that on the west of England (Cumberland and Lancashire), we find the conditions of these several members completely reversed in respect of development. Here the central calcareous member is reduced to very small dimensions, being represented in South Lancashire by marls with thin bands of limestone,* and in Cumberland by thin bands of magnesian limestone near Whitehaven, Stank, and Bispham. On the other hand, the upper and lower sedimentary beds attain great dimensions; the former, as Sir Roderick Murchison has shown, represented by the St. Bees sandstone, over 600 feet in thickness; and the latter by the Penrith sandstone, estimated by Professor Harkness to attain a thickness of 3000 feet. It is clear therefore that the sedimentary region in the north of England area has been to the westward, and the calcareous area to the eastward; and that in this group there has been a development from opposite directions of the two types of strata.†

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* These measurements are taken chiefly from sections of the Geological Survey of Great Britain.

† See my paper "On the Thickness of the Carboniferous Strata of Lancashire, &c.," 'Jour. Geol. Soc. London,' vol. xviii.

	North-west of England.	North-east of England.
	Feet.	*Feet.*
Upper Permian (Sedimentary) ..	600	50 to 100
Middle " (Calcareous) ..	10 to 30	600
Lower " (Sedimentary) ..	3000	100 to 250

I now pass on to the consideration of the physical conditions of which these interchanges of vertical development between the calcareous and sedimentary strata are the palpable representatives.

Natural Grouping of Strata on a Threefold System.—Regarding the calcareous strata as the representative of the pelagic, or deep-sea, conditions, and the sedimentary as the representative of more littoral conditions, it is to be understood that each of the three divisions of a natural group represents the *predominance* of these conditions at each successive stage, and not their existence to the exclusion of others. *We must also take as representatives of a special group that section of it which is somewhat intermediate between its extreme conditions of littoral and pelagic;* for we can easily understand that there must have been tracts in the ocean where sediment was never deposited during (for instance) the whole of the Carboniferous period, and where the only representative of the series would be the Carboniferous limestone. And, on the other hand, there must have been tracts bordering on the old land surfaces of the period where the calcareous member was scarcely represented (as in Scotland), and where sedimentary strata were formed, almost to the exclusion of others. As a matter of fact, however, it is this portion of the geological groups (between the littoral and the pelagic) which is generally preserved for our observation, as it is only on rare occasions that we meet with the actual margins of geological formations.

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* As shown by Mr. E. W. Binney, Mem. Lit. and Phil. Soc., Manchester, vol. xii., &c.

† I have not referred to the Lower Permian beds of the central counties, as the relationship of these beds to those of the north is somewhat obscure. They were probably deposited in separate basins.

But not only does a natural group represent special regions of the sea-bed, but also, we may suppose, three historical periods of formation, making up in the aggregate a geological cycle; the first of movement, the second of quiescence, and the third of movement again, terminating in those great oscillations, accompanied by denudation, which brought the cycle to a close, and produced discordant stratification. We have already seen that the formation of calcareous matter depends mainly on the absence of muddy or sandy sediment in the waters of the sea. This state of things would naturally attain predominance after the close of a series of vertical movements, accompanied by a maximum of subsidence of the land. The prevalence of sediment would be brought about during periods of disturbance, accompanied by a maximum of elevation of the land. Thus the three stages of a natural cycle going to form a geological group may be thus expressed:—

Natural Group.	Lower stage, *representing* prevalence of land with movement, *producing* chiefly sedimentary strata.
	Middle stage, *representing* prevalence of sea with quiescence, *producing* chiefly calcareous strata.
	Upper stage, *representing* prevalence of land with movement, *producing* chiefly sedimentary strata.

On the principles here stated it is easy to account for several phenomena of frequent occurrence amongst the formations of our globe. We can account for these interstratifications of calcareous and sedimentary strata, called "passage-beds," of which we have good examples, for instance, at the base of the Yoredale series of England, by supposing the alternate predominance of muddy and clear water in the sea at the margin of the pelagic and littoral regions. We can also account for the fact that a natural group of strata is rarely if ever introduced by a series of limestones, but generally by coarse sedimentary strata, often conglomerates. I question if a true natural group is ever represented by limestones in its lowest beds, and if this should happen to be the case it may be concluded that it is exceptional and due to the local absence of a lower member. A natural group is also seldom terminated by a calcareous stratum, and when this is the case (as, for instance, the chalk of England) it is owing to the local absence of an upper sedimentary member. I am not, however, prepared to say that this is invariably the case, as the Upper Silurian group of the United States seems to offer an illustration in an opposite direction.*

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* It is questionable, however, whether this is really an exception, as the Oriskany sandstone might be assumed without much hesitation to be the upper sedimentary member of the Silurian; and the "Cauda galli grit" the lower member of the Devonian series.—See 'Siluria,' 4th edit., pp. 436–7.

BRITISH FORMATIONS ARRANGED UNDER THE TERNARY CLASSIFICATION.

Applying the above principles to the classification of the British stratagraphical series, I shall give a short statement regarding each group as arranged in the accompanying table, in ascending order (see Plate), reserving to a future occasion the consideration of foreign groups.

Laurentian Group (Sir W. Logan).—The existence of this earliest known group of rocks in the British Isles was first announced to the scientific world by Sir Roderick Murchison in 1856, and again in 1859. It occupies the north-west coast of Scotland, from Cape Wrath southward to Loch Enard as well as the whole of the Hebrides. It consists mainly of highly metamorphosed gneiss, with only thin bands of limestone at rare intervals. The prevalent strike is from N.W. to S.E., and it is overlaid discordantly by Cambrian rocks, with a prevalent strike from N.E. to S.W.*

The formation as represented in Britain is manifestly incomplete, the calcareous beds with *eozoon canadense*, which are finely developed in Canada, being absent, and as Sir Roderick Murchison considers the British rock to be the representative of only the lower division of the Laurentian series as it occurs in Canada, there is a loss of one entire member. It is therefore impossible to represent this fundamental rock in our Geological series otherwise than as a mere fragment of a great formation.†

The Cambrian Group.—This group as it occurs in Britain, especially in the Longmynd, where as shown by Sir R. Murchison it lies at the base of all the Silurian series, has no calcareous representative. In the north-west of Scotland, the basement beds, consisting of hard chocolate-coloured sandstone and conglomerate‡ rising into the lofty mountain of Queenaig, are truly represented. These are surmounted by quartzites with crystalline limestones of Lower Silurian age. In Wales, on the other hand, the base is not visible; so that we find what seem to be the upper beds surmounted by the "Lingula Flags" of the "Primordial Zone." As this great formation is devoid of a calcareous representative in Britain, it cannot be regarded otherwise than as a fragmentary.

The Lower Silurian Series.—The "Lingula Flags" of Britain, being entirely composed of sedimentary strata, and exhibiting no very marked discordance in the stratification with reference to the Llandeilo series, form naturally a portion of the lowest member of the Lower Silurian series, of which the Bala and Llandeilo limestone series form the Middle, and the Lower Llandovery rocks and Caradoc sandstone, the upper sedimentary series.

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* See new geological map of Scotland, by Sir R. Murchison and Mr. A. Geikie, 1862.

† 'Siluria,' 4th edition, pp. 10–12.

‡ Ibid., p. 15.

In Bohemia, however, as M. Barrande has shown, this group, named by him "Zone primordiale," assumes a threefold arrangement, with a central calcareous member, as represented in the column of strata.

Middle Silurian.—A Middle Silurian group is not yet generally recognized, but, as Professor Ramsay has very clearly shown,[*] there is a great physical break between the Lower and Upper Llandovery beds, accompanied by the disappearance of the great majority of species of animals belonging to the Caradoc beds, while at the close of the Upper Llandovery series (Tarannon shale) there is a second break and unconformity. There are therefore apparently very good grounds for a Middle Silurian group, of which the Upper Llandovery limestone may be considered the central calcareous member.

Upper Silurian Series.—The basement beds consisting of the Derbyshire grits, flags, and slates, rest unconformably on the Middle Silurian series. This is the lower sedimentary member. The middle calcareous member is represented by the Wenlock and Aymestry limestone series. These two beds of limestone assume in this country an individuality and distinctive palæontological character, which, as Sir Roderick Murchison has shown, is not maintained by their Continental equivalents.[†] The Upper Ludlow rock and tilestones combine to form the upper sedimentary member of the group.

Devonian Series.—This natural group appears under several distinctive characters in different parts of the British Islands. Nowhere, indeed, is the series represented unbroken and complete; but in Devonshire we have probably the nearest approach to this. I shall therefore, in dealing with this great formation, call to my aid those "*breaks in succession*" which Professor Ramsay has recently dealt with in his Presidential address to the Geological Society of London.[‡]

Devonshire.—The ternary division of the series into a lower and upper sedimentary, with a middle calcareous member, seems to have been very clearly established, both by the original observations of MM. Murchison and Sedgwick, and confirmed by the recent detailed examination of Mr. Ethridge.[§] The classification here proposed differs slightly from that of these authors who have established a Lower, Middle, and Upper Devonian series; but as I find it necessary to confine the middle division to the Ilfracombe limestone series alone, the passage from the sedimentary conditions of the lower into the calcareous conditions of the middle, and from these latter into the sedimentary conditions of the upper series appears in this district to have been gradual and uninterrupted.

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[*] Presidential Address to the Geological Society of London, 1863.

[†] This view is borne out by M. Barrande, who refers the three upper limestones of the Silurian series in Bohemia to the Wenlock and Ludlow beds conjointly, finding it impracticable to make the distinction of these beds into two groups corresponding to the English series.

[‡] 1863-4.

[§] 'Quart. Journ. Geol. Soc.,' vol. xxiii., p. 580.

Herefordshire.—The Old Red Sandstone in this district and South Wales appears, from the observations of Sir Henry De la Beche, to consist of two members lying discordantly on each other, the upper member appearing to pass upwards into the Carboniferous series, the lower to graduate downwards into the Silurian. A possible explanation which I venture to offer is, that we have here the representatives of the upper and lower sedimentary members of the ternary group, of which the central calcareous member has not been deposited in this region. In illustration of this view I may point to the Trias of England, which, as we shall presently see, affords a similar example capable of ready explanation.

Scotland.—In Scotland we seem to have a succession of beds somewhat parallel to that of South Wales. Mr. A. Geikie has divided the Devonian series into three groups, each resting unconformably on that below it. But as the upper member of this threefold series is stated by him to graduate upwards in the lowest beds of the Carboniferous rocks, I have ventured in this classification to place this "Upper Old Red Sandstone" at the base of the Carboniferous series, with which it seems to be more closely allied than with the "Middle Old Red Sandstone." We have then two sedimentary members resting discordantly on each other, and leaving an intermediate gap in the succession, which the middle member ought properly to have filled, as in the case of South Wales.

Ireland.—The investigations of Mr. Jukes seem to have brought to light in Ireland, as in Scotland, a double series of sedimentary strata resting discordantly on each other.

To the unrepresented space between these members may, I think, be referred the position of the central calcareous member, and the two divisions to the upper and lower sedimentary members of a natural group. Thus we have the "Dingle and Glengariff Grits" of the lower stage surmounted discordantly by the Coomhola Grits of the upper. If the above explanation of a highly difficult problem regarding the relations of the Devonian series in Wales, Scotland, and Ireland has any approach to the truth, the entire absence of the middle calcareous member may probably be accounted for by supposing that during this stage in the geological cycle these tracts had been elevated into land surfaces, while in the Rhenish and Devonian regions the limestones of the middle Devonian group were in course of formation. Such oscillations of the sea-bed would serve also to account for the break and unconformity between the upper and lower members of the group.

Carboniferous Series.—The threefold division of this group with its calcareous central member in Great Britain has already been so fully alluded to, that it is scarcely necessary for me to add to what I have already written. I may, however, here remark that although there is a nearly continuous and uninterrupted sequence in the beds from the lower limestone shale throughout, there are both in England and Scotland occasional slight breaks, denudations, and unconformities, but that these are of an exceptional character, and of limited extent. I have already mentioned my reason for placing the upper "Old Red Sandstone" of Scotland at the base of the Carboniferous series of that country.

Permian Series.—It is almost superfluous to insist upon the threefold classification in the case of this group, as originally established by Sir Roderick Murchison and Professor Sedgwick, in the north-east of England, and more recently developed in Lancashire and Cumberland by the labours of Professor Harkness, Mr. Binney, and others. Having already described the relations of these beds (see page 361), I shall only here refer to what I consider to be the true position of the Lower Permian rocks of central England and Shropshire with reference to those of the north of England. Those who are familiar with the aspect and physical characters of the Permian beds in these two districts cannot fail to have observed that they belong to two different and distinct types. And regarding as I do the beds of central England and Shropshire as belonging exclusively to the Lower Permian series, the most probable explanation of the difference in their mineralogical characters, as compared with their representatives in the north of England, appears to be that each group was deposited in a separate hydrographical basin, disconnected by a barrier of lower Carboniferous rocks which crossed from west to east under the central plain of Cheshire and parts of South Derbyshire. Into the evidence of the former existence of this barrier I have fully entered in a paper read before the Geological Society of London in 1869.

Triassic Series.—It is scarcely necessary to observe that in Britain we have no representative of the central calcareous member of this natural group. The reasons for the absence of the Muschel-kalk and St. Cassian limestones, which on the Continent form the central calcareous member of the group, is now clearly understood. In England the basement-beds of the Keuper division rest, with a slight discordance, upon an eroded surface of the Bunter, representing a gap in geological time during which the English area was elevated into dry land, and only submerged again at the commencement of the Keuper period. I regard this case of the Trias of England, bereft of its middle calcareous member, as a parallel case to that of the Devonian group of Wales, Scotland, and

Ireland, and as throwing light upon the mutual relations of the upper and lower members of that group.

Jurassic Series.—I venture to assert that no very valid objection can be taken to the arrangement of the three Jurassic groups here adopted, and which are given in the table of geological formations. If we examine the elaborate tables of the distribution of species which Professor Ramsay has, with the aid of Mr. Etheridge, laid before the Geological Society, we shall observe that there are species common to the groups as here arranged, and that the theory of "migration" accounts for the temporary change of groups of animal remains. (See Plate.)

The Liassic series seems to admit of a sub-group if we take the marlstone (or Middle Lias) as the central calcareous member. This, however, is a distinction to which it is scarcely entitled. The upper sedimentary member of the Upper Jurassic group is only very partially represented by certain littoral and marine beds of the Middle Purbecks. Their marine equivalents, and certain antecedent strata now lost, are, however, the true representatives of this stage. That these have been denuded away from off the upper surface of the Portland limestone is, I think, made sufficiently clear by the eroded surface which this rock generally presents. On the Continent the same phenomena are presented, pointing to the absence of certain strata through denudation. On this point M. D'Orbigny says:—"Quant aux limites supérieures rien nous manque pour la séparation nette et précise qui existe avec l'étage néocomien. Cette séparation, en effet, se montre sous tous les formes, par discordances et par des discordances de dénudations et d'érosions."*

Cretaceous Series.—The close of the Upper Jurassic period is marked by a complete physical break, and, as above stated by D'Orbigny, by denudations of the Jurassic beds. This is observable all along the line of the chalk Downs through Wiltshire and Oxfordshire, where we find occasionally (as Dr. Fitton long since pointed out) the Greensand resting on different members of the Jurassic series, from the Portland Oolite down to the Coral Rag inclusive. As regards the accompanying change in the palæontological features, Professor Ramsay remarks:—"The break in the succession of *species* is as great as in any part of the Palæozoic series, and is shown by the total change of species which marks the introduction of the marine cretaceous formations."†

The Lower Greensand, Gault, and Upper Greensand, though showing in places evidence of breaks in the succession,‡ form on the whole a well-defined lower sedimentary member of the Cretaceous group. The Upper Greensand may be considered as "a passage-bed" from the sedimentary to the great calcareous central member, the Chalk, a view which seems borne out by the palæontological relations of the beds, for of the known species 20 per cent. pass up into the overlying beds.* The upper sedimentary member is lost to us, both in Britain and on the Continent, through denudation, for we find the basement beds of the Tertiary series resting everywhere on an eroded surface of the Upper Chalk, or of the Maestricht beds. On this point D'Orbigny remarks:—"Pour les limites stratigraphiques supérieures (de l'étage Danien) elles sont marquées par des discordances de dénudation et d'isolement les plus prononcées;" and as regards the enormous break in time represented by the palæontological changes Professor Ramsay remarks:—"Of the 521 species known in our Upper Chalk, all, with the exception of *Terebratula caput-serpentis*, and a few Foraminifera, have apparently become extinct during that vast period that elapsed between the close of the Cretaceous and the beginning of the Eocene period in England." It is clear, then, that the series is incomplete;—there is a missing member.

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* 'Paléontologie,' p. 563.

† Anniversary Address to the Geological Society of London, 1864.

‡ This break is shown to be large in the case of the Lower Greensand, for out of 28 species 233 are peculiar and 51 (or 18 per cent.) pass upwards.—Ramsay, *ibid.*

Tertiary Series.—The Woolwich and Reading series of Mr. Prestwich together with the London clay, form in England the natural lower sedimentary series of the Tertiary group. These were deposited in a sea open to the north and west, and at the close of this stage a general depression of the middle and south of Europe took place, accompanied by the introduction of the "Middle Eocene series" of Sir Charles Lyell. In the great nummulite limestone formation we cannot but recognize the middle calcareous member of our ternary classification, which has spread over large tracts of Europe, Asia, and Northern Africa, but is absent in Britain. Sir C. Lyell and Viscount d'Archiac have shown that these beds are represented in Belgium and French Flanders by strata characterized by three species of nummulites, which are also more abundantly developed in the limestone formation of the Alps, where it attains a magnitude and characteristically calcareous features unknown in Northern Europe. I regard this as another illustration of development from *opposite directions* of the calcareous and sedimentary members of the same natural group.

The upper sedimentary stage is represented by the black shales, marls, and sandstones of Glarus ("flysch"), and other strata of the Miocene period, of which the "molasse," a great conglomerate or breccia of Switzerland, is the best representative. In England it is doubtful if we have true representatives of this stage, which completes the range of our natural groups and brings us to the confines of the Glacial epoch.

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* See Table v., Professor Ramsay's Address.

IV. THE TRANSIT OF VENUS IN 1874.

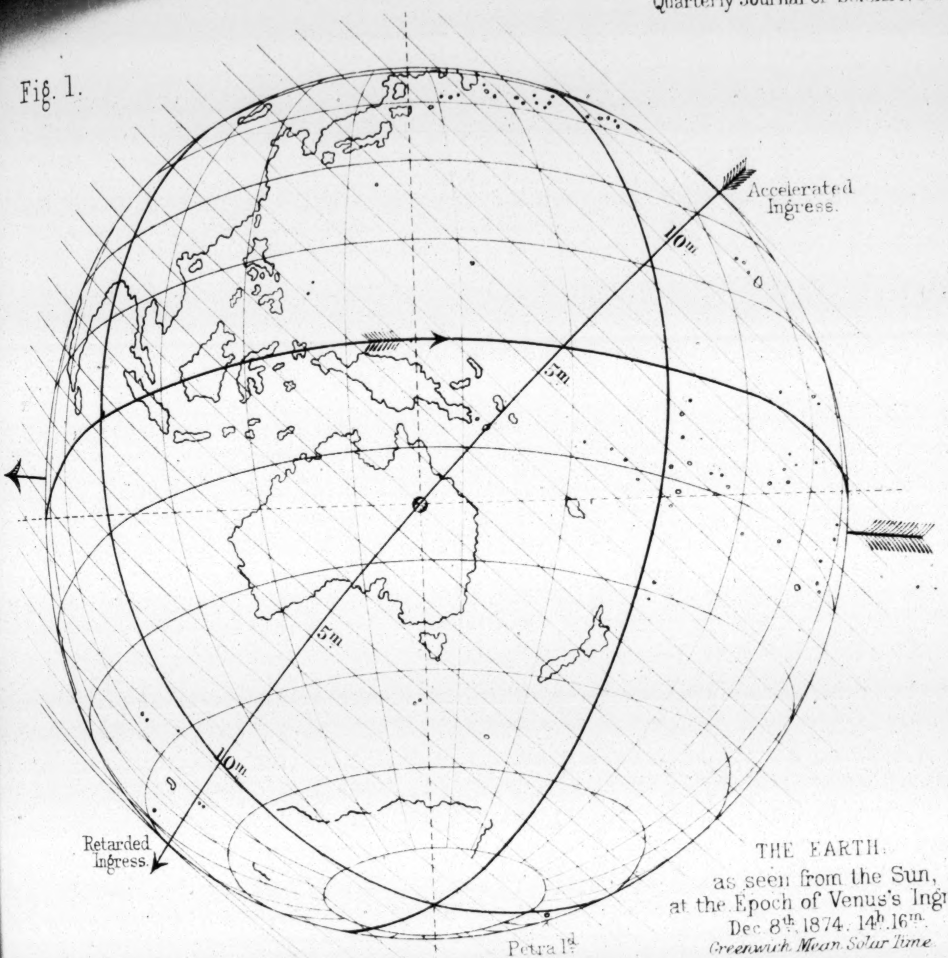
By Rich. A. Proctor, B.A., F.R.A.S.

On account of the important bearing of the transits of Venus upon the problem of the sun's distance, men of science are looking anxiously forward to the two transits which occur in the present century. Although the later of the two will not take place for thirteen years, its circumstances have already been examined. Indeed both transits were subjected to careful examination by the Astronomer Royal so far back as 1857; and since then he has continued to put forward from time to time the considerations which have suggested themselves to him as his examination of the subject proceeded. Early in the inquiry he expressed the opinion that the method founded on the observed differences of the transit's duration, as seen from opposite points of the earth's surface—which method had been the sole one employed in the treatment of the transit of 1769—is wholly inapplicable to the transit of 1874; and he suggested another method of utilizing that transit,—a method less perfect in itself, more difficult (astronomically) to carry out, and involving processes of preparation essentially different from those which would be required under the other method. To the preparations thus called for, astronomers and geographers have hitherto, I believe, solely confined themselves.

Having had occasion to examine the reasoning of the Astronomer Royal, and to test the conclusions he had arrived at, I have been led to form a somewhat different opinion of the value of the transit of 1874, so far as the simpler method of observation is concerned. I have found that, if consideration be made of internal contacts—the only phenomena on which estimates of the sun's distance have ever been founded—the actual difference of duration which can be made available in 1874, is about 35 m. or 36 m., as against an outside value of 28 m. in 1882, and an actual observed maximum of difference of 23½ m. in 1769.

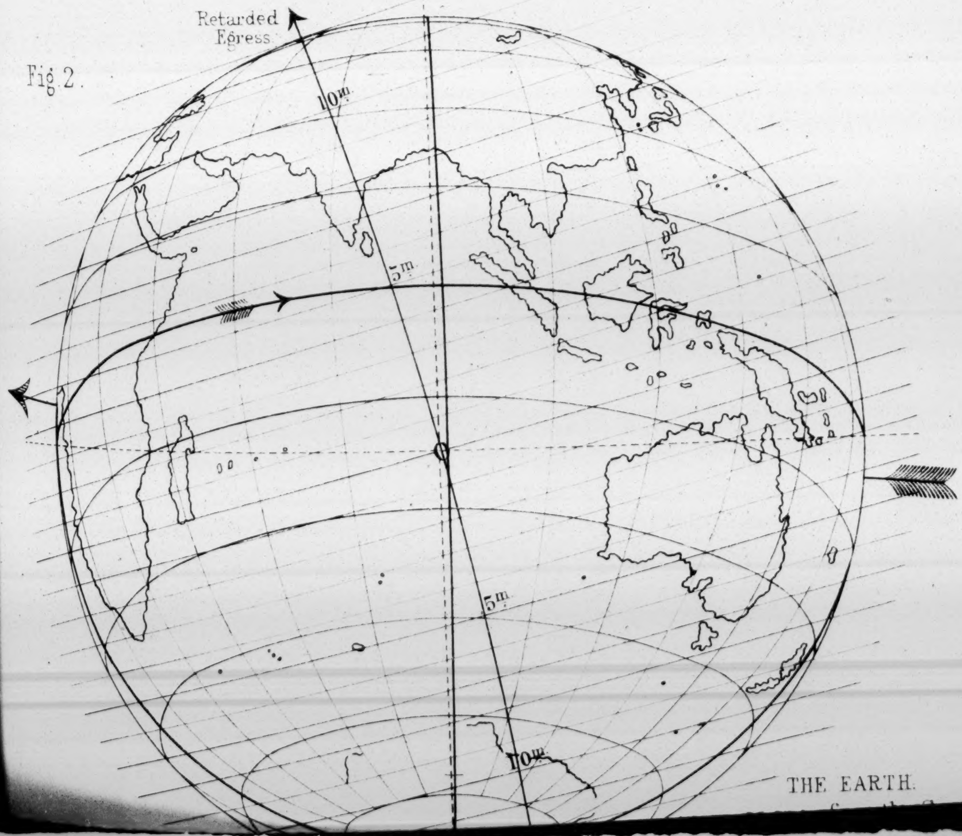
I am sensible that mere magnitude of observed difference is not the sole point on which the value of a transit depends. The rate at which the planet crosses the sun's limb is an almost equally important subject of consideration. I shall be able to show that when this point is dealt with in the manner most unfavourable to my case, the value of the transit of 1874 yet remains superior to that of the famous transit of 1769 (as actually utilized), and scarcely inferior to the most favourable estimate which can be formed of the transit of 1882. Therefore, remembering the importance which has been always attached to the observations made in 1769, and the immense advances since made in the construction of instruments

Fig. 1.



THE EARTH.
as seen from the Sun,
at the Epoch of Venus's Ingress.
Dec. 8th, 1874, 14h. 16m.
Greenwich Mean Solar Time.

Fig. 2.

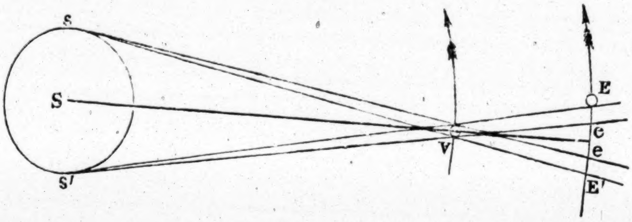


THE EARTH.

and in observing-skill, we cannot look upon the transit of 1874 as otherwise than highly valuable.

If we briefly consider the general nature of a transit, we shall be the better able to define the circumstances on which the value of any particular transit depends.

FIG. 1.



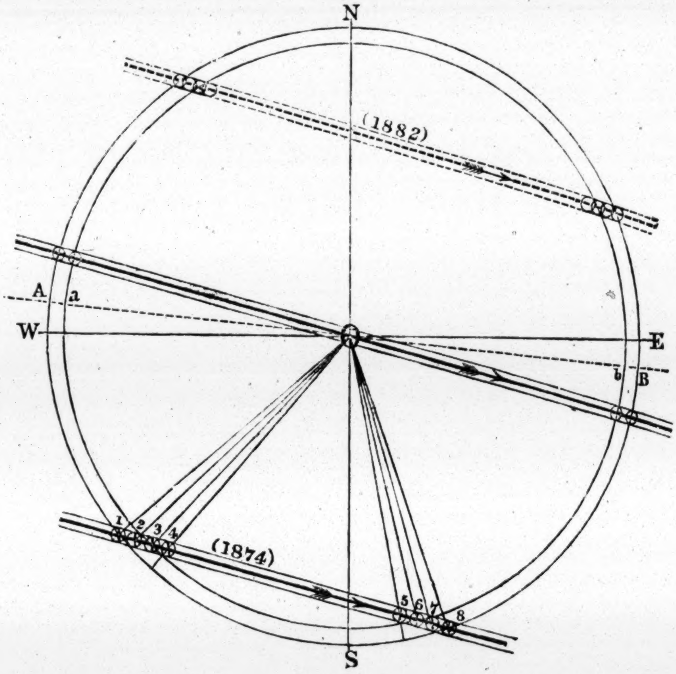
In Fig. 1, let S represent the sun, V Venus, and E the earth, the plane of the paper representing the plane of the ecliptic, so that the path of Venus (supposed to be near one of her nodes) must be conceived as inclined rather more than 3° to the plane of the paper. The arrows show the direction in which the planets move.

Conceive the sun and Venus enveloped by two double cones s e' e s' and s E' E s', one having its vertex inside, the other having its vertex outside, the orbit of Venus. These cones have a common axis, namely, the line joining the centres of Venus and the sun. Now it is clear that as Venus with her more rapid motion sweeps round the sun, the accompanying cones must overtake the earth (situated as shown in the figure), and that as they sweep onward, the earth will pass through them. As this takes place, there will occur the following eight phenomena in the given order: The forward part of the outer cone will reach (i) the nearer, then (ii) the farther side of the earth's globe; the corresponding part of the inner cone will reach (iii) the nearer, then (iv) the farther side of the earth's globe; next, the backward part of the inner cone will reach (v) the nearer, and (vi) the farther side of the earth; and lastly, the corresponding part of the outer cone will reach (vii) the nearer, and (viii) the farther part of the earth. And these several events will readily be seen to correspond to the occurrence of:—

(i) Most accelerated external contact at ingress.
(ii) „ retarded „ „
(iii) Most accelerated internal contact „
(iv) „ retarded „ „
(v) Most accelerated „ at egress.
(vi) „ retarded „ „
(vii) Most accelerated external contact „
(viii) „ retarded „ „

In Fig. 2 the actual nature of the earth's passage through the cones is illustrated, as exactly as possible, to scale. In this figure

FIG. 2.



the circles A 1 8 B and a 2 7 b represent the sections of the outer and inner cones where they cross the earth's orbit. For convenience we consider these circles to be at rest, and examine only the effects of the earth's relative motion. B O A is parallel to the ecliptic. As the earth is in reality moving from right to left in a direction parallel to B O A, and with a less rapid motion than that of the two circles A B, a b, it is clear that the earth's relative motion is from left to right. Also, as the circles are crossing A O B from south towards north (for Venus is at an ascending node both in 1874 and 1882) it is clear that the earth has a relative motion from north to south. The triple sets of lines marked with arrows show the actual direction of the earth's relative motion (the small circles representing the earth in various parts of her passage). Calculation shows that this relative motion is such that a central transit would occupy nearly eight hours. The triple lines are inclined to A O B at about 9½ degrees; and 14 degrees to the east and west line E W.

The actual path of the earth across the circles in 1874 and 1882 is indicated by the lower and upper sets of triple lines, respectively.

In considering the circumstances of the transit of 1874, I dismiss all consideration of the phenomena marked (i), (ii), (vii), and (viii) in the above table. But besides the four remaining phenomena I take into account the passage of the earth's *centre* across the circles, because Mr. Hind's elements are calculated only for these phenomena, and without considering them I should have been unable to test the accuracy of my own conclusions by comparing them with his results.

Thus the eight phenomena corresponding to the positions of the earth, numbered 1 to 8 in Fig. 2, correspond to—

(1) External contact for the earth's centre at ingress.
(2) Internal contact most accelerated at ingress.
(3) „ as seen from the earth's centre.
(4) „ most retarded.

and the four corresponding phenomena at egress.

The treatment applied to these phenomena has been the following:—Taking Mr. Hind's epochs for the external contacts at ingress and egress, I have thence calculated all the remaining epochs and the position-angles (NO1, NO2, &c., Fig. 2); the exact agreement of my estimates of such of these elements as Mr. Hind has calculated with the results he has obtained has sufficed to establish the correctness of the mode of operation. Thus has been formed the following table, in which the numbers 1, 2, 3, &c., refer to the figures in Fig 2:—

		Epoch.					Position-angle.
1,	Dec. 8,	13h.	46m.	56s.	..	..	NO1 = 130° 33′
2,	„	14	3	59	..	..	NO2 = 133 56
3,	„	14	15	57	..	..	NO3 = 136 28
4,	„	14	29	5	..	..	NO4 = 139 26
5,	„	17	43	58	..	..	NO5 = 168 58
6,	„	17	57	5	..	..	NO6 = 166 0
7,	„	18	9	4	..	..	NO7 = 163 28
8,	„	18	26	5	..	..	NO8 = 160 5

The results thus obtained have been applied to the formation of Figs. 1 and 2 (Plate), in the following manner:—

Rejecting phenomena 1 and 8 as no longer concerning us, the triple sets of phenomena 2, 3, 4, and 5, 6, 7 (see Fig. 2), are alone considered. Properly speaking, we should form an orthographic projection of the earth as supposed to be seen from the sun at each of the six epochs corresponding to these phenomena. But no error of importance will be introduced if we take the epochs of the two central passages, 3 and 6. All that will be necessary is to remember that in considering accelerated or retarded ingress, the earth in Fig. 1 (Plate) must be supposed rotated backwards or forwards respectively, through the arc due to about 12 minutes' or 13 minutes' rotation respectively, while corresponding charges must be supposed applied to the earth, as seen in Fig. 2 (Plate), at the corresponding epochs at egress. It must be remarked further that Figs. 1 and 2 (Plate) will be found not to correspond to the hours of Greenwich mean solar time, which are affixed to them, but to the corresponding hours of apparent solar time.* It is clear that the conditions of a transit have nothing to do with our horological arrangements, but only with the actual aspect of the earth as supposed to be seen from the sun.

Fig. 1 (Plate), then, represents the earth as she would appear from the sun when in the positions marked 2, 3, or 4, in Fig. 2 (Woodcut), or in any intermediate position. In a similar way Fig. 2 (Plate) represents the earth as she would appear when in the positions 5, 6, or 7, or in any intermediate position.

The lines which lie side by side across the earth's face in Fig. 1 (Plate) represent the actual position of the edge of the large circle (a b of Fig. 2), at intervals of one minute, counted with reference to the moment of central passage. We notice that while the large circle takes but about 12 m. in sweeping across the north-eastern hemisphere, it occupies more than 13 m. in sweeping across the south-western. This obviously agrees with the facts exhibited in Fig. 2; since it is clear that the nearer the earth approaches towards the middle of the line marked 1874, the slower is her rate of approach towards O.

Considerations of precisely the same sort apply to Fig. 2 (Plate), which will be at once understood when examined with reference to the three positions of the earth marked 5, 6, and 7, in Fig. 2 (Woodcut).

It must be here remarked that as respects all this part of the inquiry there is no doubt or difficulty whatever, the calculations involved being of the most elementary character. But we may stay a moment to inquire how far the results exhibited in Figs. 1 and 2 (Plate) agree with those which have been obtained by the Astronomer Royal; because, although there is no difficulty in the work thus far, a different method has been pursued by him in obtaining corresponding information. In obtaining those points of the earth marked "accelerated ingress," "retarded ingress," "accelerated egress," and "retarded egress" in Figs. 1 and 2 (Plate), the Astronomer Royal has employed the terrestrial globe adjusted with reference to the epochs of the passage of Venus' centre across the centre of the sun, the phenomena being supposed to be seen from the earth's centre. This would correspond to the passage of the centre of the small circles, marked 1, 2, 3, &c., in Fig. 2 (Woodcut), across a large circle midway between the circles A B and a b. He has assumed the position-angles at ingress and egress to be equal to NO1 and NO8. Neither the method nor the assumptions are strictly exact (as Mr. Airy has himself pointed out), and no correction has been made for the equation of time. It seems to me questionable whether the results are quite near enough for practical purposes. They lie severally about 315, 920, 760, and 230 miles from the positions I have obtained for the corresponding points. These corrections seem to me to appreciably affect the question at issue. The following rough description of the situation of the four spots referred to applies, however, almost as well to the Astronomer Royal's results as to mine :—

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* The equation of time on December 8th is nearly 8 m. additive to mean time.

Most accelerated ingress takes place at a spot far to the north of Owhyhee; most retarded ingress in a place far to the west of Kerguelen's Land and Crozet Island. Most accelerated egress takes place near the Antarctic continent in longitude far to the east of Victoria Land; most retarded egress takes place in the north-east of European Russia.

The actual longitudes and latitudes of these places I have calculated to be, in order :—

	Latitude.	Longitude.
(1)	39° 45′ N.	143° 23′ W.
(2)	44 27 S.	26 27 E.
(3)	64 47 S.	114 37 W.
(4)	62 5 N.	48 22 E.

We come now to considerations which require to be closely attended to, as they involve the gist of the whole matter.

If stations (1) and (4) were identical, it is clear that an observer there, seeing most accelerated ingress and most retarded egress, would observe the absolute maximum duration of transit. So if the stations (2) and (3) were identical, an observer there would see most retarded ingress and most accelerated egress, and so observe the absolute minimum duration of transit. Or even if observers at stations (1) and (4) could be brought into communication by means of the telegraph,* as also those at (2) and (3), it would be possible to render available the total difference of twice 25 m. 6 s., which actually marks the durations of transit in 1874 considered with reference to the whole earth. This difference of 50 m. 12 s. would exceed more than twofold the observed difference in 1769.

But under the actual circumstances what has to be done is to secure a station as near as possible to both the stations (1) and (4), and so situated that the sun shall be fairly raised above the horizon at the epoch of the internal contacts both at ingress and egress; and the like for stations (2) and (3). The examination of Figs. 1 and 2 (Plate) will show that there is a difficulty in fulfilling each set of conditions. The point marked "accelerated ingress" is far away on the darkened hemisphere at the moment of "retarded egress," and *vice versâ*. The point marked retarded ingress in Fig. 1 (Plate) has moved far upwards towards the centre of the illuminated hemisphere at the epoch represented in Fig. 2 (Plate), that is, far away from the point marked "accelerated egress."

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* Nothing but the consideration of expense renders this impossible or even difficult.

It was the consideration of these circumstances which led the Astronomer Royal to pronounce the transit of 1874 altogether unfit for the purpose of observing the durations of transit, as seen from opposite parts of the earth's surface. And he suggested that four sets of observers should be sent to watch each of the four phenomena,—accelerated and retarded ingress and egress; and that by determining the exact longitudes of their stations, and so (with the aid of exact chronometers) learning the exact Greenwich time of each phenomenon, the transit might be rendered available through the comparison of the results *inter se*. Clearly the elements of difficulty and the probability of error are seriously increased in this method as compared with one which practically requires but the simple estimate of duration, and scarcely admits of being affected by chronometer errors. However, let us note that by this method an observed difference of at the outside 24 m. might be obtained;—not more, because the sun cannot be observed when too close to the horizon, and because also of the difficulty of finding suitable stations.

Now let us see what can be done towards the utilization of the transit of 1874 by the simpler method:—

Suppose the northernmost station taken in latitude 60°, that is, along the uppermost parallel in the figure. As the whole duration of transit is but about four hours, and day lasts about six hours in this latitude on December 8, we may take a place two hours on the left of the central meridian in Fig. 1 (Plate), knowing that the same place will be (at the end of transit) two hours to the right of the central meridian in Fig. 2 (Plate); and at one epoch the sun will be one hour risen, on the other one hour from setting. Doing this we find that the station (which lies in Siberia, not far from Lake Baikal) falls in Fig. 1 (Plate) on the sixth cross-line from the centre, and in Fig. 2 (Plate) above the tenth cross-line. In other words, the transit as seen from this spot exceeds the mean by $(6 + 10\frac{1}{4})$, or $16\frac{1}{4}$ minutes.

Next for the southern station. Here we have a wide choice. If we put our observer on Petra Island (a place probably very little suited for astronomical observations) we get (from Fig. 1, Plate) ingress retarded by 8 m., and (from Fig. 2, Plate) egress accelerated by 12 m., or in all the duration of transit falls short of the mean by 20 m. If we take the place marked out by the Astronomer Royal for observing the transit of 1882, a place near Repulse Bay, in east longitude 105°, we get ingress retarded by 9 m. and egress accelerated by 9$\frac{1}{2}$ m., or in all transit shortened by 18$\frac{1}{2}$ m. If we take Victoria Land, in south latitude 70° (say), and east longitude 172°, we get ingress retarded by 6 m. and egress accelerated by 11$\frac{1}{2}$ m., or in all transit shortened by 17$\frac{1}{2}$ m. If we take Enderby Land, in east longitude 50°, we get ingress retarded by 11$\frac{3}{4}$ m. and egress accelerated by 8$\frac{1}{2}$ m., or in all transit shortened by 20$\frac{1}{4}$ m. These four southern stations, combined with the northern station before considered, give a total difference of duration of 36$\frac{1}{4}$ m., 34$\frac{1}{4}$ m., 33$\frac{1}{4}$ m., and 36$\frac{1}{2}$ m. respectively. Also, as it would not be well to trust to a single northern station, it may be noticed that any part of the nearly circular region extending from Lake Baikal to Saghalien, and from north latitude 40° to north latitude 60°, might be used for observing the increased duration without important disadvantage as compared with the station already considered. Also, Crozet Island, Kerguelen's Land, and other parts of the Antarctic continent besides those considered, give abbreviated transits of considerable value. Thus for Crozet Island the abbreviation is no less than 17 m.; for Kerguelen's Land, 16 m. Even Macquarie Island, Royal Company Island, Hobart Town, and parts of New Zealand, might serve as useful subsidiary stations.

And now to compare the value of the transit of 1874 with that of 1882. We see that by the method of durations we get a difference of more than 36 m., whereas the maximum difference is 50$\frac{1}{5}$ m. The Astronomer Royal has shown that for the transit of 1882 it is possible to take positions for observation (not by any means more favourable than those above considered) which give at the outside a difference of duration bearing to the maximum the proportion of 341 to 400. The maximum difference in the case of the transit of 1882 is only 32 m. 48 s., in place of 50 m. 12 s. as in 1874. Reducing 32 m. 48 s. in the proportion of 341 to 400, we obtain the period 27 m. 57 s. in place of the difference of 36$\frac{1}{2}$ m. which the most favourable situations in 1874 will give.

If we assume that the value of a transit is not to be estimated according to the magnitude of the observable difference, because the rate with which the planet crosses the sun's limb is diminished in exactly the same proportion, and the error of observation correspondingly increased, we have the relative values of the transits of 1874 and 1882 as

$$\frac{36\frac{1}{2}}{50\frac{1}{5}} \text{ to } \frac{28}{32\frac{3}{4}}$$

or almost exactly as 6 to 7. But this extreme result, although as it stands it is altogether opposed to the theory of the utter valuelessness of the transit of 1874, is obtained on an assumption which is unsupported by evidence. Mr. Stone has shown that the formation and breaking of the black ligament connecting Venus with the sun at the true moment of internal contact is an instantaneous phenomenon in favourable weather. In unfavourable weather the error in the observation of this phenomenon should depend rather on atmospheric causes—the length of the periods of atmospheric disturbance, and so on—than on the rate of the planet's separation from the sun's limb. If this is so, the transit of 1874 is superior to that of 1882 in the proportion of 36½ to 28, or more than 9 to 7. If the truth lies between these extremes, the transit of 1874 may be fairly taken to have a value bearing to that of 1882 a proportion midway between 6 : 7 and 9 : 7; that is, the proportion of 15 : 14.

In any case no doubt can remain that the transit of 1874 is highly valuable, when dealt with in reference to the mode of observation we have been considering; and it seems clear that when all the difficulties and all the sources of error involved in the second method are duly considered, the simple method, founded on observed differences of duration, is to be held altogether more likely to give satisfactory results. I believe, therefore, that such preparations as geographers are already thinking of with reference to the choice of suitable southern stations for observing the transit of 1882 ought at once to be undertaken in connection with the transit of 1874.*

V. ON THE TEACHING OF NATURAL SCIENCE IN SCHOOLS.

By EDWIN LANKESTER, M.D., F.R.S.

ALTHOUGH amongst educated men there is a generally accepted opinion that the teaching of one or more branches of natural science ought to be introduced into schools, there is still much indifference on the subject in the public mind, and no definite view of the nature and extent to be given to such teaching anywhere. Anyone looking at the character of the human mind, and the accumulated knowledge resulting from its activity, must feel that the attempt to educate the human being without supplying some knowledge of the great facts of natural science is a one-sided proceeding. It is clear that, without a definite knowledge of facts, the art of being able to *talk* and *write* about them, or to *number* them, is of comparatively little importance. So obviously is this the case, that at first sight it is a matter of wonder that the teaching of the facts of natural science has not been more largely introduced into schools. The difficulty of introducing natural science into schools is of two kinds. In the first place, our school system has grown up from a period when there was little or no natural science to teach: commencing at a time when all knowledge was locked up in the languages of Greece and Rome, and precise science was confined to mathematics, those branches of culture have been universally introduced into all our high schools. Under these circumstances, the teaching of the classics and mathematics has become a kind of institution around which the feelings of those who have been educated under their influence have clung as around a political system whose existence is regarded as the palladium of the State. Propose to add anything or take away anything from this system, and you are immediately met with the demand to look at the long list of statesmen, warriors, scholars, and divines who have attained distinction under its influence. It is vain to reply that these worthies might have attained more distinction had they known more of natural science, or that probably their distinction was entirely independent of their knowledge of Latin, Greek, and mathematics. It is this feeling which meets us in the Universities and higher schools; and the unhappy tendency of the middle class to produce a miserable copy of this teaching brings down the sentimental objection to teaching natural science into the lower ranks. The only way in which this opposition can be overcome is by attacking the Universities. It is here that the natural sciences meet with their first rebuff. A very small proportion of the vast funds appropriated for education at Oxford and Cambridge are given to those who pursue natural science; and, although public opinion has forced both our Universities to be more favourable to the students of the natural sciences, it is very questionable whether anything short of legislative interference will induce the University authorities to get out of the groove in which they have run for centuries.

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* Since the above was written the subject of the coming transits has been considered by Mr. Stone, than whom no one is better qualified to pronounce authoritatively on the principles which should guide us in utilizing those phenomena. He is of opinion that observations made when the sun has a less elevation than 10° would be altogether useless. This principle enables me to considerably augment my estimate of the relative superiority of the transit of 1874, with reference to the simpler mode of observation. In fact, the only southern stations which had seemed suitable in 1882 must at once be rejected; and thus we may say of that transit what had been said of the other, that the simpler mode "fails totally" with respect to it. On the other hand, the value of the transit of 1874 is scarcely at all affected by the application of the principle.

Mr. Stone considers the superiority which I have ascribed to the simpler method to have a real existence, but to be so slight (the values of the two modes being as 6 to 5) as to be unimportant. This is just; but the distinction between this view and the imagined total failure of the method seems not the less to require attention.

There are, however, schools which are not dependent upon the example of our Universities. There are the National Schools of England and Ireland, the British and Foreign Schools, and Girls' Schools everywhere. In these schools they do not pretend to teach Latin or Greek, why it is difficult to understand, for if the study of the classical languages is of the value in training the mind that the advocates of their teaching assert, then the minds of all those who are not taught them must suffer, and thereby a great loss is incurred by the community. But let this pass. Some people believe in a male mind and a female mind, and other subdivisions of mind; so that what is strengthening and elevating to one class of mind is weakening and depressing to another. Thus our schools, as a whole, present an immense variety of subjects to be taught, but all agree in the exclusion of natural science. The real reason, however, why natural science is not introduced into the latter class of schools is no sentimental love of the subjects they teach, but the difficulty of teaching facts. Natural science cannot be taught by books; and the whole system of schooling, except in girls' schools where they teach sewing and music, is carried on by the agency of books. To teach the natural sciences, recourse must be had to *things;* books are of little or no use. Physics and chemistry must be taught by experiments; mineralogy and geology must be taught by specimens of minerals and rocks; botany and zoology by plants and animals. Neither teachers nor parents are prepared for this invasion, and the consequence is that little or no natural science is taught, even where the bugbear of Latin and Greek does not exist to frighten it away.

At the same time, whilst these difficulties exist with regard to teaching natural science in our schools, the study of natural phenomena has gone on during the last century with increasing rapidity. The Universities of the continent of Europe have in almost every instance acknowledged the position of natural science. In France and in Germany this has been remarkably the case; and in the latter country so great has been the progress, that she fairly ranks intellectually as first amongst the nations of the world. In England the necessity of natural knowledge for the exercise of certain professions, as that of the medical man and the engineer, has caused the foundation of schools from which have proceeded men who have cultivated the natural sciences with great success. We are not, therefore, without some practical knowledge of the beneficial effects produced by their study. That it may be safely introduced into our schools without injuring other studies is obvious from the fact that, when some branch of natural science has been taught in a school, the boys have been found not to have suffered in their knowledge of Latin and Greek. The result of a limited experiment at Rugby has been "that the school, as a whole, is the better for it, and that the scholarship is not worse." It is also found by the examiners in classics at the University of London and the Colleges of Physicians and Surgeons, that the point of excellence attained by the medical student who has to study natural science is not lower than that of general students who do not study natural science at all. If this be true, then it shows us that our present system confers less benefit than if the whole of our scholars were compelled to study the natural sciences. This is also the experience of Germany, where the extensive study of natural science does not deprive her of classical students who may challenge the rest of the world for accurate criticism and profound scholarship.

Another reason for introducing natural science into our schools is seen in the fact that some boys have an innate aptitude for acquiring the facts of natural science, whilst they dislike or are entirely unfitted for classics and even mathematics. In this way the employment of scientific facts generally throughout the schools of the kingdom would assuredly be the means of raising up men who would devote themselves to this subject, and enrich the world with new discoveries and new applications of scientific principles.

We may say, however, that whatever may be the bent of a lad's genius towards classics and mathematics, a knowledge of the principles of scientific inquiry would go far to correct the acknowledged defects of such education. The observation of individual facts, the arranging them in laws, and reasoning from the known to the unknown, involved in the inductive and deductive processes employed by the natural philosopher, could not fail to provide a discipline of benefit to the scholar as well as the mathematician.

Another advantage of the cultivation of these sciences is, that it places the individual who studies them more closely in contact with the thought and experience of the age in which he lives. All the great activity of life depends much more on the progress of the natural sciences than the culture either of classical or mathematical knowledge; and a man in almost every position of life is placed more or less at a practical disadvantage who is not acquainted with the principles of scientific discoveries. Who is there with a knowledge of natural science that has not been grieved to hear an eloquent discourse marred by ignorance of the laws that govern the simplest natural phenomena! Who that has been examined before a Committee of the Houses of Lords or Commons, has not wondered at the ignorance displayed by our legislators of the commonest facts known to the scientific man! Again, how many of our scientific witnesses bring away from our courts of criminal justice impressions of the thoroughly false estimate that advocates, jury, and judges take of the simplest natural facts brought before them!

Another reason why the principles of natural science ought to be universally taught, is the fact that the daily health and life of mankind depend upon their obedience to the laws that govern the external world in which they are placed. The human body is so constructed that no one can understand the nature of the laws by which it exists without deriving benefit therefrom. A slight knowledge of the nature of the atmosphere in which we live, of the properties of heat, of the composition of materials about us, may frequently be the means of saving life. In every occupation in which the human being can be employed, he must act in accordance with laws which have been discovered and understood by others, and every one must be directly benefitted by possessing such knowledge. To leave such a precious possession as this to the mere accident of a man finding out its value in after-life, is to play with the mercies of Providence, and to merit the punishment that attends the infraction of Divine laws.

In the last place, we may speak of the high intellectual pleasure afforded by that special exercise of the mind which attends the pursuit of natural science. There is, no doubt, pleasure afforded in poring over the beauties of ancient poets, and satisfaction given in the perfectly accurate results that follow the solution of mathematical problems; but we question if the gratification in either case is so great as that of contemplating the truths of physics, of chemistry, or of life. Especially are these studies ennobling in the highest degree when they are pursued with the feeling that all the great facts and phenomena of the universe are revealing the mind of God to man. The mind of the human being who has not studied the great laws by which God is governing and upholding the natural world, cannot be so capable of understanding the questions of man's responsibility and relation to God as he whose mind has, in the feeblest way, been led to contemplate God's nature in his works.

But supposing the point settled of the desirableness of introducing the study of natural knowledge into our schools, to what extent ought we to teach it, how ought it to be taught, and where are the teachers to come from?

With regard to the first question, a distinction ought to be made in the beginning as to the object of teaching the natural sciences at all. On the one hand, we may teach one branch or all these sciences for the sake of imparting desirable knowledge to the mind; or, on the other hand, we may use them with the object of training and strengthening the mind for action in the pursuit, generally, of the facts of the external world. It would not be impossible, we think, consistently with the time boys spend at our higher schools, to carry them through the chief branches of natural science in the course of their studies; and especially could this be done if the teachers were themselves skilled in science generally, and understood the relation of one subject to another. Unfortunately, the way in which science is pursued in England affords little chance at present of our seeing a body of skilled teachers who, whilst they could take a class successfully through one branch of subjects, should understand their relation and bearing to another class of subjects. The only profession that could supply this class of men is the medical; but then the man thus educated and fitted for teaching, would make a much handsomer income by the practice of medicine than anything he could get by teaching science in schools. At the same time, it might be worth the while of some of our better schools to tempt men thus educated, by better salaries than are given to ordinary school teachers, to enter upon such a course of instruction.

By commencing the teaching with boys ten or eleven years old, they might be carried through the elements of all the natural sciences in a scheme like the following:—

First year: Experimental physics, embracing the laws of sound, heat, light, electricity, and the elements of mechanics.

Second year: Chemistry, embracing more especially the metallic elements, and a knowledge of the forms and composition of minerals.

Third year: The chemistry of the organic elements, and the consideration of those compounds which enter into the constitution of plants and animals.

Fourth year: The structure and physiology of plants, with the principles of systematic botany.

Fifth year: Comparative anatomy, and the general principles of zoology, and the physiology of the lower animals.

Sixth year: Human physiology, and anthropology.

This course of study might easily be varied, according to the judgment of the teacher; and the organic sciences might even be introduced from the commencement.

Such a plan as this could only be pursued with able instructors, and when ample time is given to acquire the knowledge imparted. It would be quite impossible to carry it out where only two or three hours a week are given to natural sciences. Five or six hours a week, for eight or nine months in the year, would be the least that would be required for such a course as the above.

This is one of the greatest difficulties connected with the working of natural science classes in schools, that none of the old masters are prepared to afford a sufficient amount of time for anything like giving a satisfactory amount of instruction. The writer once asked the master of a large school if his pupils were taught natural science, to which he answered, O yes! we teach all the natural sciences. "In what way?" it was asked, and the answer was, that an occasional course of lectures was delivered by distinguished professors from the neighbouring city. This gentleman would have been greatly surprised if a schoolmaster teaching the natural sciences were to propose to teach Latin and Greek by occasional courses of lectures. This is a fundamental error, if possible to be got rid of from the minds of men educated in classics and mathematics. They all regard natural science as an *amusement*, as something to be encouraged by way of relaxation in leisure hours, but never as the serious business of life. Until this notion is thoroughly eradicated from the minds of our teachers, little or no progress will be made in the teaching of natural sciences.

But suppose we have only two or three hours a week to give to this kind of teaching, the question comes, What is the best use that can be made of them? Provided a competent teacher can be found, we have little doubt as to what subjects would be found most useful and advantageous. When the object is to give the mind a training in the principles of inductive science, there is no branch of knowledge more fit for this purpose than chemistry. The facts which it comprises are most varied, whilst their combination and arrangement admit of almost mathematical accuracy. The processes of observation and reasoning are called forth, whilst the experiments which must necessarily be performed excite the interest of the pupil to the highest degree. The facts when acquired are of the utmost practical utility. They lie at the foundation of most of the practical arts of life, and are the foundation of the higher sciences of vegetable and animal physiology. At the same time, care must be taken to place this science on its right footing. The pupils themselves should be made to perform the experiments. To teach chemistry by mere lectures with experiments is a defective method. To teach it by books without experiments is worse than useless.

There is another subject so daily useful, so important, that although not to be placed by the side of chemistry as a training science, it nevertheless demands the earliest attention, and that is human physiology. The information conveyed in this branch of knowledge is so individually valuable, that we think it might be successfully shown that no advantage obtained by any other kind of knowledge is so directly beneficial to mankind. It may no doubt be objected that physiology presents some of the most difficult problems that can be mastered by the human mind, and that as it is the last science that we have recommended to be taught in schools, under no circumstances ought it to be the first. It is no doubt true that it is better, where time can be given to the inorganic sciences, that they should precede physiology; but when it becomes a question about which of the sciences it is most beneficial to know something, then we have no hesitation in placing human physiology first. Nor is this science so difficult to teach as its complex problems would lead philosophers to think. Every pupil has in his own body the means of performing experiments, and can watch the functions which it is the province of physiology to teach. It is not proposed to teach physiology on account of its satisfactorily developing mental processes, but on account of its principal facts being necessary to be known in order to preserve health and save life. The great bulk of even educated people have little idea of the immense destruction of life that takes place every year through our ignorance of the most ordinary laws that regulate human life. The rudiments of physiology could not be taught in nine-tenths of the schools of Great Britain without rebuking the disregard paid to its laws in the ventilation of rooms, the distribution of the hours of study and relaxation, the conduct of exercises, and a hundred other points connected with health. The homes of the poor and middle classes of this country are the constant sources of disease and death, not because of poverty or injudicious economy, but from sheer ignorance of the simplest laws by which God provides for the health and life of his creatures. The whole country is full of mourning for those who are stricken down with fevers and other contagious diseases, with scrofula and consumption, yet it can be demonstrated that the larger proportion of these diseases could be prevented by a knowledge of the preventible causes of disease and death. To defer teaching this subject till it can be taught at some distant time after school-days are over, is to forego one of the greatest advantages that can be conferred in teaching the natural sciences at all. This subject is seldom taught, and to no class completely except to the medical profession; and although they have done nobly in urging upon the public mind the necessity of sanitary legislation arising out of their physiological studies, there is no public opinion to sustain sanitary law. Our legislators, our clergymen, our judges, our vestrymen, our electors, our people, are alike ignorant of the structure and functions of the bodies they live in, and disease and death stalk through the land from year to year with undiminished strides. The great hope of the sanitary reformer lies in the introduction into schools of the teaching such an amount of physiological knowledge as would form a public opinion that would second the efforts of the Legislature to secure for the people of England houses and homes free from the easily preventible causes of disease and death.

But, dwelling on this subject for a little, let us suppose that no effort is made in a school to introduce natural science as a means of training the intellect of the scholar; has not physiology a higher claim to attention than most of the subjects introduced into reading lessons? The favourite subjects for such exercises are history, geography, and natural history. Such reading is extensively introduced into our lower schools and into girls' schools. Everybody is agreed that children must read about something; and if this is the case, why should they not read about the structure of their own bodies and the functions on which their life depends? Surely it would be as well that the time for reading should be occupied in an account of Harvey's discovery of the circulation of the blood or Jenner's more important discovery of the prevention of small-pox by vaccination, as on the invasion of Britain by Julius Cæsar or the discovery of America by Columbus. Even the inveterate prejudice of those who think that nothing can be taught without the aid of books might be thus accommodated, and books on Physiology pointed out that might be read in schools, whether boys or girls are taught in these schools.

From what we have said, it will be seen how difficult it is to introduce the subject of natural science at all into schools. Where an individual teacher sees the importance of the subject it can always be introduced, but where there is indifference on the part of the teacher there is no pressure from without. We may say confidently that with regard to the success of any school, from a dame's school to an upper school or a University, it is a matter of perfect indifference to parents whether they teach natural knowledge or not. Hence we are driven to seek some power external to our whole scholastic system. There is no doubt our Universities possess this power. In a Report recently published by the House of Commons* it is stated that, "although no more than 35 per cent. even of the boys at our great public schools proceed to the University, and at the majority of schools a still smaller proportion, yet the curriculum of a public school course is almost exclusively prepared with reference to the requirements of the Universities and the rewards for proficiency that they offer." If this be the fact, it is then obvious that our Universities are really obstructive of the increasing intelligence of the age; and however much they are cultivating the "sweetness" of our youth, they cannot be said to increase their "light." This obstructive influence is felt not only in the higher schools, but in all educational establishments where English is spoken. The one great drawback to teaching natural science in the colleges of the United States of America is the example of the English Universities. Recently, in one of the largest Dissenting colleges in England the most feasible way of reducing the expenditure of the institution was in diminishing the modicum of teaching that had previously been attempted in natural science. The late principal of the Liverpool Collegiate Institute, when desirous of introducing natural science teaching into the school, was plainly told by the merchants of Liverpool that they only wished him to teach those branches of knowledge to their sons by which he had gained his own eminence. It seems very clear then that one great object to be kept in view in introducing natural science into education is to change the policy of those who rule in our Universities.

At the same time there are some cheering signs of movement both in our English Universities and in our public schools. At Oxford, Christchurch has opened a very complete chemical laboratory.

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* Report of a Committee appointed by the Council of the British Association for the Advancement of Science to consider the best means for promoting Scientific Education in Schools. 1868.

Although there is little teaching of natural science in the colleges, Christchurch gives annually a junior studentship, Magdalen College a demy-ship, and Merton College a post-mastership for these subjects. There is also a scholarship founded by Miss Brackenbury at Balliol College for natural science; and another lady, Miss Burdett Coutts, has founded a geological scholarship for University graduates. There is also the Radcliffe travelling fellowship given to candidates who, having taken a first-class in natural science, are preparing for the practice of the medical profession. At Christchurch also there are two Lee's readerships in natural science, and recently fellowships have been given at Merton, Queen's, and Pembroke, for the same subject.

At Cambridge there is a natural science tripos, but little encouragement is afforded by the colleges for its study. There are scholarships at King's, Caius, Sidney-Sussex, St. John's, and Downing. The latter college has recently given a fellowship for natural science, and Trinity College has appointed a lecturer on the same subject. At St. John's there is a chemical lecturer and laboratory. In reference to Cambridge, the report above referred to says, "At present public opinion in the University does not reckon scientific distinction as on a par with mathematical or classical; hence the progress of the subject seems enclosed in this inevitable circle,—the ablest men do not study natural science because no rewards are given to it, and no rewards are given for it because the ablest men do not study it." The great question for the consideration of the people of England to whom these Universities belong, is, How is this vicious circle to be broken? In Cambridge there are also lectures on various branches of natural science adapted to a medical education.

The London University requires a certain amount of elementary knowledge of natural science in its matriculation examinations, which is classed under the heads of mechanics, hydrostatics, hydraulics, pneumatics, acoustics, optics, and chemistry. At the examination for B.A., a further knowledge of astronomy and animal physiology is required. The London University also gives degrees in science, and there is a B.Sc. degree, and two years after a D.Sc. is granted.

The College of Preceptors gives an honorary fellowship, for which one branch of science, either chemistry, natural history, or physiology, is required.

The Agricultural College at Cirencester has fifty pupils, who are engaged entirely in the study of natural science. There are professorships of geology, botany, chemistry, agriculture, and physics.

Amongst our high schools a beginning to teach natural science has taken place. At Rugby there are lectures on mechanics, geology, and botany, and these form part of the regular school course. A

Natural History Society has also been established at Rugby, to which the senior scholars are permitted to belong, the Transactions of which are before us, containing reports of papers and meetings held during the year 1868.

Natural science is encouraged at Harrow by a voluntary examination, to which all the boys are invited, and they are placed according to their merits. There is no systematic teaching, but many of the boys make great attainments in science, and some of them have already distinguished themselves in the scientific world. There is also a Scientific Society at Harrow, which meets at fixed periods under the presidency of one of the masters. A museum has been formed, and the masters speak highly of its beneficial influence in the training of the boys. At the International College at Spring Grove, the natural sciences are made a part of the general training of the boys. Competent masters have been appointed to teach these branches of science, and Dr. Schmitz, the intelligent head-master of the school, speaks very confidently of the success of the plan.

Intermittent attempts have been made to teach natural science in various other schools throughout the kingdom, but the want of determination in the masters and encouragement on the part of parents very often lead to the entire abandonment of any sustained efforts to proceed in this course. There seems little doubt that if young men of scientific tastes would fit themselves to become teachers in schools without applying themselves to the practice of some profession, they would find ample employment for their ability in tuition. They must, however, be prepared to insist on their own terms, and times and methods of teaching, as the condition of mind of the majority of those who undertake to teach the young, whether male or female, is utterly blank as to the nature, value, or methods of teaching any branch of natural knowledge.

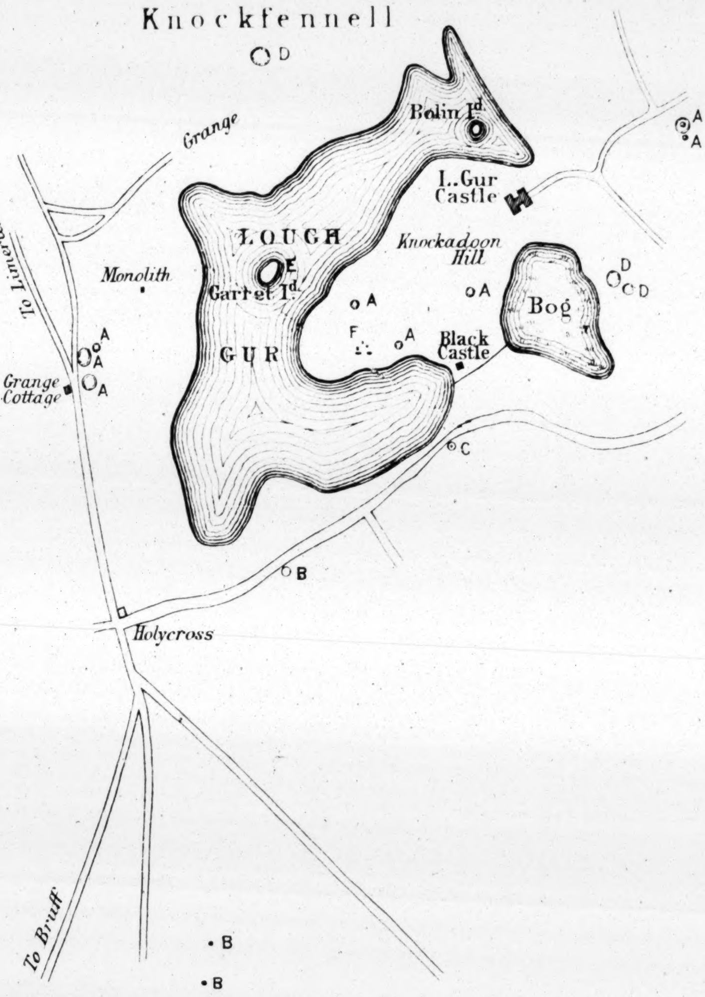
VI. THE PRE-HISTORIC ANTIQUITIES OF AND AROUND LOUGH GUR.

By Professor Harkness, F.R.S.

(With a Sketch-Map.)

At the distance of about 3 miles north of the town of Bruff, Co. Limerick, is an irregularly formed sheet of water known as Lough Gur. Including its islands and the district immediately surrounding it, this lake has been one of the most prolific sources of pre-historic remains in Ireland.

Near its margins there are several stone, and stone and earth circles, and from the abundance of remains of this character the lake has derived its name, which is, according to the statement of



A.	*Stone, and Stone and Earth Circles.*
B.	*Cromlechs.*
C.	*Cist.*
D.	*Remains of Stone Forts.*
E.	*Crannoge.*
F.	*Remains of Hut Enclosures?*

SKETCH MAP OF LOUGH GUR
AND THE
SURROUNDING COUNTRY.

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Mr. John Fitzgerald, who is resident near it and who has a thorough knowledge of the Irish language, a corruption of Lough Cirgor, or the lake of the stone circles.

The most perfect of these circles is near the west side of the lake and close to Grange Cottage. This owes its perfection to Mr. John Fitzgerald, who has preserved it with most zealous care, and whose great interest in the pre-historic remains of the neighbourhood of Lough Gur has enabled him to recognize every spot near its margins where relics of this kind occur.

This fine circle is about 150 feet in diameter.* Internally it is made up of large blocks of conglomerate and limestone, the former being generally of greater size than the latter, and one of which, on the north-east side of the circle, is about 9 feet high, by 4 feet in thickness, and 6 feet in breadth. There are about sixty of these upright blocks of conglomerate and limestone, and these make up the inner portion of the circle.

Outside this circle of stones, and supported by it, is an earthen rampart, which at its crest is about 9 feet higher than the ground surrounding it. This rampart has a gentle curve outwards, except at one spot, and its base is about 34 feet wide. On the E.N.E. side of the circle a passage has recently been discovered by Mr. Fitzgerald, leading into the enclosed portion. This passage, which is about 2 feet wide, has the sides lined with flagstones. The area within the circle is considerably higher than the surface of the ground which surrounds it, and this area has been raised by artificial means, its level being less than 4 feet below the crest of the rampart.

A short distance northwards from this fine circle the remains of another are seen. This second one is entirely composed of blocks of stone. An old road runs through the western side of this second circle, the portions which remain are, however, sufficient to afford a knowledge of its original size. Its diameter is larger than the fine stone and earth circle at Grange Cottage, being 170 feet. Almost immediately adjoining this larger imperfect circle, and on its N.E. side, there is another, which is also composed solely of blocks of stone. This is a small circle, and is still very perfect. It consists of fourteen large irregularly shaped masses of rock, which have a squarer outline than the blocks forming the other circles. The diameter of this circle is only 55 feet.

A short distance N.W. of these three circles, and in a field adjoining the Limerick high-road, there are other traces of pre-historic remains. These occur in the form of a few large blocks of stone arranged in a double row. They may have originally formed the western side of the large imperfect circle, having been removed from thence when the road was being made. There is also in the same field a large cup-shaped depression about 210 paces in diameter, but whether this is a natural or an artificial production there is not sufficient evidence at present to determine.

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* For this, and the other measurements of the pre-historic remains around Lough Gur, I am indebted to Mr. Fitzgerald.

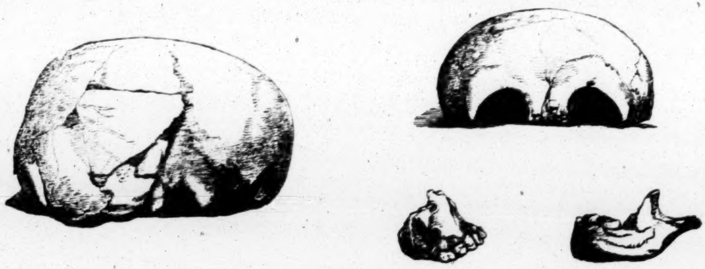
The eastern side of Lough Gur is margined by a very irregular outline, and the surface here is much bolder than on the western shore. Before the surface of the waters of the lake was reduced to its present level, a large island, about half the size of the lake, occupied the eastern side. This was, however, separated from the mainland only by shallow water in a narrow channel and boggy ground; it now forms a peninsula, and is known as Knockadoon Hill, the summit of which rises about 200 feet above the level of the lake, and the sides of which exhibit several bold rocky escarpments.

On the west side of Knockadoon, about 34 perches from the border of the lake, another stone and earth circle is seen. This, which is about 90 feet in diameter, is made up of a double ring of upright flaggy limestone blocks which have been obtained in the immediate neighbourhood, and which, when contrasted with the blocks forming the circles on the western side of the lake, are of small size. The interval between the outer and the inner row of flagstones is about 4 feet. The flags, as in the case of the large stone and earth circle at Grange Cottage, are placed very near each other, and the interval between the two rows is partially filled in with earth. Inside this circle are several detached blocks of rock of comparatively small proportions.

Another double stone circle filled in with earth occurs on the south side of Knockadoon, about 15 perches from the shore of the lake. This is somewhat smaller in size than the one just alluded to. It also has several detached blocks in the area enclosed by it. One of these, near the N.E. side, is a flaggy mass placed on its end in the ground, and being about 3 feet high, forms a small monolith. The antiquity of this monolith is well indicated by the weathered state of its surface, which is deeply eroded by atmospheric action. Mr. Day, F.S.A., Mr. Fitzgerald, and myself opened the ground immediately west of this monolith, and at the depth of little more than a foot from the surface discovered human bones. These consisted of fragments of ribs, fragments of bones of the arms, a nearly perfect lower jaw, a portion of the upper jaw, the frontal and parietal bones of the skull very nearly entire, with the temporal and occipital bones in a less perfect state. These bones had belonged all to one individual, a young person of from six to eight years of age. The bones of the head exhibited features of an interesting nature, and the lower jaw had also peculiar characters.

As regards the latter, these consist of its great thickness, especially where the molars are inserted; the form of the malar angle, which is very obtuse, being 143°, and the relation of the condyle to the coronoid process, which are much removed from each other, giving to the hind portion of the jaw a form which belongs to a very aged individual, or to that of an infant, rather than a young person. The upper jaw is very prognathic in its outline; and this circumstance may have had some influence in giving to the lower jaw its singular modifications.

The form of the skull is strongly platybregmate, being broad and short, with the upper portion singularly flattened. Its greatest length is about $6\frac{1}{8}$ inches; and its greatest breadth, which is from the centre of the parietal bones, is about $5\frac{1}{2}$ inches. The width of the frontal bone is about $4\frac{1}{4}$ inches; and the circumference of the skull measured from the frontal sinus by the juncture of the sagittal with the occipital suture is about 18 inches. The frontal bone is peculiar in form. A line drawn along its ascending portion, and meeting another drawn along the flat upper surface of the skull, would form a right angle. The ascending portion of the frontal bone is about $1\frac{1}{2}$ inch high, and, curving rapidly over upwards for about an inch, meets the flattened surface of the head. The orbits have the upper portions small, with a very rounded outline. The bones of the skull are also very thin.



Human Skull and Lower Jaw, discovered near Monolith, Lough Gur.

With these human bones a small fragment of the antler of a stag, about $1\frac{1}{2}$ inch long and $\frac{3}{4}$ of an inch in breadth, was found. Surrounding the monolith which marked this burial-place was a rude circle of small stones, about 8 feet in diameter.

A few yards west from the monolith in this circle, is a small patch, enclosed, also by a rude ring of small stones. This has an elevation of about 9 inches above the ordinary level of the surface, continued within this stone and earth circle. On opening this patch, and at the distance of about 18 inches beneath the surface a stone cist was discovered. The sides of the cist were composed of limestone flags, and the ends were also formed of the same materials. A flag of the same kind also covered the cist. This covering did not however extend over the whole of the chamber formed by the flags, the portion in which the lower extremities had reposed was uncovered. This, however, may have resulted from stones breaking the lid, as above the cist several pieces of rock were found. The lower portion of the cist was formed of small portions of flaggy limestones, which had been arranged with considerable care, in the form of a pavement when the cist was being made.

Several fragments of human bones were met with in this cist. These consisted of fragments of ribs, a portion of a femur, two os calces, a portion of a lower jaw, and other fragments. The portion of the lower jaw had appertained to a young person of from six to eight years of age, and one of the os calces seems referable to the same individual. The other os calcis appears to have belonged to a nearly, if not quite, full-grown person; and the fragment of the femur, which had the epiphyses fully united, seems also to have formed part of the skeleton of an adult. The length and thickness of the thigh bone when compared with the corresponding bone of the skeleton of a modern full grown individual indicate a person of small stature.

The length of the cist also points out the small size of the body which had occupied it. This was not more than 4 feet 2 inches long; and as its depth did not exceed 18 inches, it is not probable that the body was buried in a crouching position.

The remains in this cist had been to some extent disturbed; but this had resulted from the burrowing of rabbits, the bones of which were found along with the human remains. Associated with these there occurred also fragments of the bones of swine. A portion of the right side of the upper jaw of this animal contained in the cist exhibited the last molar tooth, which was of a large size. The condition of this fragment indicated that it had long been buried; its state being similar to that of the human bones, and altogether different from the rabbits' bones, which have a very recent aspect.

Among the bony fragments of this cist were two upper incisor human teeth of rather a large size, and having the cutting surfaces considerably worn.

The two bodies in this stone and earth circle seem to have been placed originally in a north and south direction, the heads being towards the latter.

It would be premature, from these human remains, to draw any general conclusions as to the characters of the race which at an early period inhabited the shores of Lough Gur; and which buried its dead within the circles so abundant near this lake. Further evidence will probably be obtained from some of the other circles. So far, however, as these human remains enable us to judge, they tell us of a broad-headed people, with small eyes and of short stature, approximating more nearly to the present Fins and Laps than to any other race of men. And this circumstance is in accordance with many of the conclusions which have been arrived at concerning the pre-historic races of other countries.

Another small stone and earth circle occurs on the east side of Knockadoon Hill, at the distance of about 60 perches to the N.E. of the one just referred to. This, however, is in an imperfect condition.

Below the circle from whence the human remains were obtained, and to the west of this, about 35 perches, on the margin of the lake, there are several irregular-shaped small patches of ground enclosed by blocks of rock. One of these, which has an oblong form, is about 30 feet long by 18 broad. These enclosures occur in a small dell. They are the results of human labour, and have probably surrounded the huts of the ancient inhabitants of this shore of Lough Gur.

At the distance of about half-a-mile N.E. from Knockadoon Hill, on the farm of Ballycullen, a very large stone and earth circle is seen. It is about 155 feet in diameter; and this circle, both on its outer and its inner side, is composed of large upright blocks having earth in the interspace, the width of the circle being about 14 feet. In size this circle slightly exceeds the very perfect one at Grange Cottage. It is not, however, in so good a state of preservation, and has an earth fence intersecting it. It encloses within it another circle of the same character, which is about 49 feet in diameter, and which occupies a central position in the area embraced by the larger circle.

A few yards beyond the southern margin of the large circle another small one occurs. Its diameter is 35 feet; it is composed of flagstones, which touch each other. The area enclosed by this circle is raised to the height of about 3 feet above the surface of the adjoining ground. In this circumstance this small circle is analogous to the large one at Grange Cottage. The elevation of its interior has probably resulted from the falling down of a tumulus enclosed by the ring of flagstones. In the case of the raising of the level in the large circle several tumuli may have combined to produce this. In some instances these tumuli have probably fallen down from natural causes, but in many cases they have been destroyed by the hand of man under the impression that beneath them were buried hidden treasures.

That these several stones, and stone and earth circles near Lough Gur enclosed the places of sepulture of an early race is rendered probable, not only by the occurrence of human bones in them, but also by the circumstance that similar circles, which are found in other countries, afford evidence supporting the same inference. Local traditions have assigned them to a very different origin. By some they are regarded as Druid Temples; but this mode of disposing of their origin is of recent introduction into Ireland, and in general the peasantry look upon them as ancient fortifications. None of them bear a name indicative of a burial-place, and as there are no ideas prevalent that such is their nature, they have probably belonged to a race of men antecedent to that from whence the Celtic population of Ireland has had its origin.

In a field a short distance to the north of the circles of Ballycullen, many stone cists containing human bones have been found. In this field there are at present no remains of circles. It is, however, probable that these did formerly here exist, and that their stones have been taken away for building cottages, several of which are near this spot.

Besides circles of stone, and of stone and earth, the neighbourhood of Lough Gur also contains the remains of Cromlechs. One of these is seen on the south side of the lake, at the distance of about a third of a mile E.N.E. of Holycross, which is on the Limerick high-road; and two others occur at the distance of about three-quarters of a mile south of this spot. These Cromlechs are locally known as "Giants' Graves."

On the south-east side of Lough Gur, a short distance from the ruin known as Black Castle, there is a stone cist of considerable size made up of large slabs of flaggy limestone. This, which is also known as a giant's grave, is 16 feet 8 inch. in length, 5 feet 5 inch. wide, and 2 feet 2 inch. high. Its covering still to a considerable extent remains, and consists of large heavy limestone flags. The object for which this was designed was most probably like that of the cromlechs, namely, for a place of sepulture.*

There is also on the western side of Lough Gur, near Grange, a very fine monolith. It consists of a mass of conglomerate, and is about 12 feet high by 7 feet broad, and from 3 to 4 feet in width. Its north-west side is flat, but its other sides are irregular in shape. It leans somewhat towards the S.E., and on this side, close to its base, the limestone is seen *in situ*. There are no carvings nor marks of any kind visible on this monolith.

The numerous stone erections already referred to do not exhaust the pre-historic remains of the neighbourhood of Lough Gur. On the summit of Knockfennell, a hill which rises above the northern shores of the lake, there are traces of a building made of large flat blocks of stone which had a circular outline, the diameter of which is about 42 paces. Traces of similar erections, which are even more distinct than that of Knockfennell, can also be seen on the summit of another hill, which is on the eastern side of a bog between this hill and Knockadoon. Here two circular stone erections can be detected, the most perfect of which is 142 feet in diameter.

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* Local tradition has given to this cist, and to many others of the same kind, the Irish name of *Leabthacha Dhiarmada is Ghrainne*, or of the beds of Diarmaid and Grainne. The story of these individuals belongs to the mythical period of Irish history. The former is represented as the companion of Finn Mac Cumhaill, and the latter, a daughter of the monarch Cormac Mac Art, who, in order to escape being made the wife of Finn in his old age, eloped with Diarmaid, his young and handsome follower.

It consists of a wall in some portions about 4 feet in height and about 11 feet in thickness, composed of large masses of rock laid regularly one upon the other, and in the interior backed up by a great accumulation of smaller broken flagments of limestone; the latter being probably designed to produce a level surface immediately within the wall. The other circular erection, which is only a short distance from the one just alluded to, has a diameter of 138 feet, and is in a less perfect state.

These circular erections of stone, which occur on the hill-tops overlooking Lough Gur, have no mortar in connection with them. They appear to have been of the same character as the Staigne Fort in the Co. Kerry, and they probably formed strongholds. The positions in which they have been placed near Lough Gur have great natural capabilities for defence, and afford views over a large tract of country.

Although the race which erected the circular stone strongholds seems to have had no knowledge of the use of mortar, the builders of these strongholds appear to be referable to a period more recent than the constructers of the circles and other sepulchral remains which have been previously referred to.

Besides the numerous pre-historic remains which occur in the neighbourhood of Lough Gur, the lake itself also affords objects of antiquity of a similar character. Around Garrets Island, which is near the centre of the lake, and particularly towards its southern side, are to be seen many upright piles, especially when the surface of the lake is low. Garrets Island itself seems to be an artificial production, for the surface of it, which is only slightly elevated above that of the lake, is made up of broken fragments of rock, and these fragments are likewise seen extending from its shores into the water of the lake. Previous to the lowering of the lake's surface, which took place about thirty years ago, a large part of this island was under water; the only portion at that time visible was occupied by the ruins of a small castle or tower, which had probably been built by one of the Earls of Desmond. It is doubtful whether even this portion is not an artificial production; but in consequence of the rubbish from the fallen walls of this building, the surface which supports it cannot be seen, and there are circumstances connected with it which lead to the conclusion that it is not a natural surface,

At the time when the level of the lake was lowered, and the area of the island increased, the land laid bare was found to be covered with an enormous accumulation of bones. More than a hundred cart-loads of these bones were removed and sold to the dealers in such articles. For many years subsequent to the lowering of the surface of the lake, this spot continued to be a very prolific source of bones, for during the potato famine, the poor of the town of Bruff, when the water was low, obtained a scanty livelihood by collecting and selling bones from this locality.

The bones procured here consisted of the remains of *Bos longifrons*, the heads of which almost all exhibited a fractured front, produced by the blow which had killed them. Bones of the pig and goat were also found, the heads of which were likewise marked by broken frontal portions. Together with these were the bones and antlers of the stag, and some skulls, jaws, and other bones of a dog of a large size, and with an elongated muzzle. These dogs seem to have belonged to a race which was the progenitor of the now extinct rough-haired Irish greyhound. A few human remains were found along with the other bones. Some of these consisted of lower jaws, generally of a large size, and a heavy outline.

Besides bones, this island has been a very prolific source of stone implements in the form of polished celts. It has also yielded great quantities of bone pins and piercers. Stone discs about 3 inches in diameter and ½ an inch in thickness, beautifully rounded in outline, and with finely smoothed surfaces, have also been among its products. Similar discs have been obtained in other parts of Ireland in connection with Crannoges. For what purpose they served it is difficult to conceive, and nothing analogous to them has been found among the remains of the pile-dwellings of Switzerland.

Judging from its nature and the character of the several kinds of remains which Garrets Island has afforded, there is every reason for concluding that this island is the relic of a large Crannoge. History contains no authentic records of this, although some of the Irish Crannoges were occupied so late as the seventeenth century.

The portion of country around Lough Gur had been long in possession of the Desmonds before their forfeiture in the reign of Elizabeth; and the occupation of the Lough Gur crannoge must have been antecedent to the Desmond possession. That this crannoge of Lough Gur is of an ancient date, is proved by the implements which have been derived from it. Very few iron weapons have been obtained in it. Bronze celts of either the socketed or winged type, are rare in connection with it. The earlier and simpler form of bronze celt has been more frequently procured from it; and pure copper celts, the earliest form of metal, implements have been among the products of this Crannoge. These copper celts are of a ruder type than the earliest form of bronze weapons of the same character, and in outline they approximate more nearly to the antecedent stone celts.

It is, however, for stone implements that the Crannoge of Lough Gur is famous, and of these many may be seen in the Museum of the Royal Irish Academy, in some of the public museums of England, and also in several private collections.

NOTICES OF SCIENTIFIC WORKS.

THE POLAR WORLD.*

The distribution of animal and vegetable life upon the surface of our globe is regulated, with remarkable exactness, by the quantity of sunshine which falls upon each parallel of latitude. In other words, the measure of solar energy which, as luminous, or calorific, or chemical force—to say nothing of electrical power—becomes active upon any spot of Earth, determines, not merely the life which shall exist upon that spot, but the variety of that life, be it vegetable or animal.

In the tropics, where

> "—— The long sunny lapse of a summer-day's light
> Shining on, shining on, by no shadow made tender,"

quickens the circulation of those fluids which are the life-stream of plant and animal alike, we find an exuberance of vitality. The vegetable world assumes a gigantic character, and bursts into flowers and fruits, in which nature's chemistry has produced the deepest dyes and the most luscious juices. The animal world also revels in an excess of life, and every passion is stimulated to the utmost by the influence of radiant forces, which are the beginning and the end of organized being. There men are

> "Souls made of fire, and children of the sun
> With whom revenge is virtue."

In the temperate zones all nature assumes a milder aspect; trees and shrubs, flowers and fruits, animals and man, are in the enjoyment of a more subdued existence; and every phenomenon, whether physical or physiological, is marked by the weaker influence of the solar power. As we advance towards the arctic or antarctic zones we find a gradual decline in the manifestations of vital power, and every organized creation assumes a peculiar character, which strikingly marks the struggle for existence under the difficulties of a diminishing quantity of light and heat. At last we arrive at a region where vegetable life appears limited to the reindeer-moss, and animal existence is restricted to such creatures as can make a snow cave their home, and support the heat necessary for life, by gorging themselves with fuel, in the shape of masses of fat, washed into their stomachs with large draughts of animal oil.

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* 'The Polar World; a Popular Description of Man and Nature in the Arctic and Antarctic Regions of the Globe.' By Dr. G. Hartwig. Longmans, Green, & Co. 1869.

'The Polar World; a Popular Description of Man and Nature in the Arctic and Antarctic Regions of the Globe,' is devoted to a full consideration of those cheerless regions near the poles of our Earth, and the conditions of existence within their ice-bound circles. The frigid zone of the northern hemisphere is strikingly cut off from the temperate regions by belts of forest. We have a zone of evergreen coniferæ, which gradually shades off towards the north into a treeless waste. These wastes, known as "barrens" in North America and "tundri" in Russia, are produced by the ice-cold winds which sweep unchecked over the islands or the flat coasts of the Polar Ocean, and for miles and miles compel even the hardiest plant to crouch before the blast and creep along the ground. These "tundri" represent in a striking manner the peculiar phenomena of arctic life. In the winter an awful silence, interrupted only by the melancholy hoot of a snow owl or by the yelp of a hungry fox, reigns supreme over this vast expanse. But during this period of frigid repose, nature has been garnering her stores, and with the awakening spring she pours over air and sea and land a teeming luxuriance of life, which draws from the south an army of destroyers. "Eagles and hawks follow the traces of the natatorial and strand birds; troops of ptarmigans roam among the stunted bushes; and when the sun shines, the finch or the snow-bunting warbles his merry note. While thus the warmth of summer attracts hosts of migrating birds to the arctic wildernesses, shoals of salmon and sturgeons enter the rivers, in obedience to the instinct that forces them to quit the seas and to swim upwards, for the purpose of depositing their spawn in the tranquil sweet waters of the stream or lake. About this time, also, the reindeer leaves the forest to feed on the herbs and lichens of the tundra, and to seek along the shores, fanned by the cooled sea-breeze, some protection against the attacks of the stinging flies that rise in myriads from the swamps. Thus during several months the tundra presents an animated scene, in which man also plays his part. The birds of the air, the fishes of the water, the beasts of the earth, are all obliged to pay their tribute to his various wants, to appease his hunger, to clothe his body, or to gratify his greed of gain."

Dr. Kane observes, "No eider-down in the cradle of an infant is tucked in more kindly than the sleeping-dress of winter about the feeble plant-life of the arctic zone." Ere yet the destroying blasts of winter sweep over earth and ocean, the light and feathery snow has carefully covered up every organized thing; and in a state of repose, resting on or in the earth, kept warm by its snowy mantle, the plant and the animal await that awakening which comes with the rising of the sun above the horizon.

To the contemplative mind nothing can be more interesting than to read, in the pleasant words of Dr. Hartwig, of the way in which the God of Nature has established his everlasting laws, by which the balance of existence is unerringly maintained. It is not possible, even if it were desirable, to follow our author through his several chapters—each of them interesting. All the lands which are spread out around the North Polar Ocean are described from the best authorities, and described in such a way that the reader believes them, as he reads, to be the result of Dr. Hartwig's personal observation. The plants and animals of the earth and seas are all graphically described; and the peculiar phenomena which attend their existence, under the extreme conditions of a polar winter and an arctic summer, are most fully and faithfully examined.

Living as we do in the temperate regions of the earth—complaining bitterly if our winter temperature falls much below the freezing point of water—we are astonished to learn from the narratives of the voyages of Belcher and of Kane, that their ships' crews endured the temperature of nearly 100 degrees below that point,—when chloric ether became solid, and strong chloroform exhibited a granular pellicle on its surface. Kane tells us, as examples of the readiness with which man adapts himself to the conditions of climate, that "George Riley, with a vigorous constitution, established habits of free exposure, and active cheerful temperament, has so inured himself to the cold, that he sleeps on our sledge-journeys without a blanket or any other covering than his walking-suit, while the outside temperature is − 30°."

One of the secrets of healthful existence under such conditions is to be sought in the food taken into the stomach to maintain the internal temperature. Within the tropics where the solar heat excites the animal machine to the utmost, but small internal force is required, and there fruits and succulent vegetables are all that are necessary to maintain life. We advance to the temperate regions of this Earth, and then we find that man becomes a devourer of animal food, this diet becoming, of necessity, more and more carbonaceous as his dwelling-place is situated nearer to the poles. Within the arctic circle we find men feeding on fats, and the miserable Samojede is found eating pounds of blubber at a meal, and drinking quarts of seal oil.

Notwithstanding much that has lately been written asserting—at the same time as the materialistic philosophy is decried—that brute matter lives by virtue of mere motion, no one can study the relations of animals and plants to powers, forces, energies (call them what you will) which are external to themselves, without becoming convinced that light and heat and electricity are agents ever active in maintaining Life. Whether we examine life in the tropics or at the poles, we find provisions carefully, beautifully designed, to equalize the power acting within the living organism, with the force which is active from without upon it. Throughout nature we see that life is maintained by the effort ever made to maintain the equilibrium of forces. A positive and a negative—a plus, minus—is found everywhere in the material universe, and, as the jar of Leyden owes its power to the effort it makes,—almost as if a sentient thing,—to equalize the conditions of its inner and its outer coating in relation to electrical power, so is there an analogous condition of this kind at work everywhere. This is perhaps more strongly shown in the phenomena of heat than of any other power, and nowhere is it more strikingly exhibited than in those regions where the deprivation of the sun for a long period reduces external nature to the extremity of cold. Those who can read this popular book with such a touch of philosophy in their minds as we have imperfectly indicated, will derive a double charm from the volume. Those who go to it merely for the interest which ever belongs to a well-written book on strange lands, will not be disappointed. They will find Man in what would appear to be the most wretched condition in which it is possible for him to exist, living with a certain amount of enjoyment; his very animal necessities are made so many ministers of contentment. Any one who will read with care the relation given by Dr. Hartwig, must rise from his task with his conviction strengthened that a superintending Providence alone could produce the remarkable results which astonish the traveller in the polar regions. To borrow some of the author's words, the influence on the development of vegetable and animal existence, of the long polar winter nights, and its fleeting summer, is amongst the most striking of natural phenomena. To picture Man waging the battle of Life against the dreadful climate of the high latitudes of our globe—as the inhabitant of their gloomy solitudes, or as the bold investigator of their mysteries—is to bring into striking contrast the highest and the lowest operations of mind, and to show how nearly equal are the animal conditions of him who is born amidst the eternal snows, and of him who would pierce the barriers of ice and knows what wonders lie enchained within them. Dr. Hartwig has written, for a foreigner, a book in capital English. He has, as he says, a "great variety of interesting subjects, embraced within a comparatively narrow compass," and he has conveyed much solid instruction under an entertaining form. To every one the 'Polar World' must prove a book of interest, and to many, especially to the young, it cannot fail to be a volume full of instruction.

SLEEP.*

The "physical basis of sleep," as some of our modern biologists would perhaps be disposed to call the physiological phenomena which attend that mysterious condition of the higher animals, is admirably treated in the little work before us; and we cannot do better than draw attention to its suggestive pages, as we believe a close study of the subject will throw fresh light upon those psychical powers of man concerning which so little is known and so much has been written.

In the first portion of his work the author explains the physiological cause of sleep with great clearness, and his theory appears to be borne out by our present knowledge of the subject. Popularly described, it is this: The brain is the organ of thought; when the brain is working, waste proceeds; when that waste has continued for some time, reparation is necessary; full vessels and a rapid circulation favour expenditure of the tissue, and a feebler and smaller current conduces to repair.† When the activity of the brain lessens, or when by a voluntary act it ceases, the diminution of the circulation is effected through the increased activity of the sympathetic ganglia which partially close the arteries that supply the brain, and put a stop to the physiological action which is necessary for the exercise of the mental powers. To facilitate the inactivity of the mind which is necessary to give rest and reparation to the brain, all the external avenues to the senses are closed, and so the mind is no longer disturbed by sensory activities, and is turned inwards, so to speak, upon itself only.

In sound sleep, then, it is to be presumed that little or no cerebral waste is going on, and when the reparation is complete we awake in the natural order of events. The author tells us that there are numerous causes of awakening, but they may "all be reduced to one ultimate action, namely, revoking the force of the ganglia upon the arteries, and reopening the arterial current throughout the brain." ‡

Many interesting phenomena connected with the sleeping state are ably discussed by the author. He treats of the entire absence of the power of hearing in some exhausted sleepers, as for example, the wearied soldier whose slumbers are not disturbed by the roar of cannon, so powerful is the hold of the sympathetic ganglia over the brain in sleep. Also of somnambulism, where certain senses are quite inactive and certain phases of the mind at rest, whilst others are wide awake:—"Some awakening of thought, consciousness, and will, recovered tactile sensibility, control over the muscles of the body and limbs, an open eye and dilated pupil; but obscure vision or blindness, dulness of hearing or deafness, and withal, after relapsing into sleep and complete awakening, no recollection of the purposes or occurrences of the somnambulistic state;"* and this condition he accounts for by the theory that one set of arteries which supply a certain part of the brain are fully dilated, whilst another set which supply the remaining portion of the brain are partially closed, sleep being "due to contraction of *all* the arteries of the brain, and somnambulism to that of the carotids only."†

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* 'On Going to Sleep.' By Charles H. Moore: Robert Hardwicke.

† The author is here quoting Mr. A. E. Durham on the 'Physiology of Sleep.'

‡ P. 57.

If the closure of certain arteries, which supply the brain with blood, brought about by nervous influence, is conducive to sleep, it follows that any cause which diminishes the quantity of blood circulating in the brain will have a similar effect; and the author says that "many examples of sleep arising upon the ligature, compression, or obstruction of the carotid trunks, enable us to conclude decisively that the diminution of the arterial current in the brain which occurs at the instant of sleep is no mere concomitant occurrence, but its actual cause." He might have adduced evidence of a kind more familiar to the general reader. Putting the feet in hot water causes an increased circulation in those members, and by drawing the blood from the brain, induces sleep. Sometimes a reaction ensues during the night; the feet become cold, the blood sets in the direction of the brain, and the patient awakes. On the other hand, the hydropathic treatment is in this respect more effective. When the feet are put into cold water and well rubbed, both whilst they are in the water and subsequently, an improved circulation is maintained throughout the night, and a sound unbroken sleep is the result.

Again, any person who finds it difficult to obtain rest, may probably succeed by lying down upon his back and doubling his pillow so that it fits into the back of his neck. The circulation is thus evidently impeded, for we have often found a drowsiness to supervene almost immediately on assuming this attitude.

Whilst the author thus describes the proximate causes of sleep under ordinary circumstances, he takes care to mention that the state may be banished by the exercise of the will; and that the will may also produce it. But this is nothing more nor less than saying that the mind is the active agent, and the brain the passive instrument; and exactly here it is that we believe his work to be so suggestive in regard to man's psychical powers. That in the long run "mens sana in corpore sano" is true, and that the exercise of active mental power requires a sound and well-ordered physical frame, no one will for a moment deny. But just as the most powerful physical exertions are sometimes successfully put forth by an exhausted man, the most violent display of emotion evinced by one who is prostrate, or as the most brilliant efforts of the intellect burst from an expiring thinker, so, too, the mind can at any time assert its supremacy over the active, or even the wearied instrument of its operations, and can say, "Obey me, so shall it be!" "I desire to sleep, although I have but just awoke." "I desire to sleep now, and to awake at such an hour." "You need rest, but I desire you to remain active. I *will* not sleep." All these things we can say to our brain and it must obey! How inconsistent are these facts with the teachings of some modern physiologists, who would have us believe that the brain is a self-acting thinking machine, and originates the thoughts which it conveys.

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* P. 49.

† Pp. 52–55.

We have no space to deal with other phases of the subject, such as the physical causes which exclude thought in spite of the will, rendering the machine incapable of action, but trust that we have said enough to show how deeply interesting and suggestive is the unpretending little work which has served as the basis of these observations.

On Molecular and Microscopic Science. By MARY SOMERVILLE. 2 vols. Murray.

THE attention which has been given of late years to the study of the molecular constitution of matter, and the interesting discoveries which have been made, have evidently suggested to our remarkable countrywoman the work before us. Unless we are greatly mistaken, Mrs. Somerville's original idea was to show, by collecting all the evidence within reach, that the molecule of inert matter and the organic molecule were influenced by the same set of forces or energies. As we see the inorganic group of atoms compelled to assume a determinate form under the influence of forces which always manifest, to a greater or a less extent, polarity, so we discover that the organic molecule—the primary cell—is equally the result of the operation of similar physical agencies. The materials which constitute the amorphous mountain masses, whenever they are free to arrange themselves, assume a geometric form. The microscopic examination of any rock, indeed, exhibits the struggle between the desire—if the word may be used in reference to brute matter—to crystallize, and the mechanical power, pressure, which prevents it. Remove in the slightest degree the pressure, and the inert molecules undulate into form, and crystallizations appear—a mute prophecy, as Coleridge has it, of the coming vegetation. All the elements found in the organic creation, whether we take for our examples the vegetable or the animal world, are discovered in the inert, inorganic constituents of our planet. By what processes are carbon, nitrogen, hydrogen, and oxygen, which we find so abundantly in the three ancient elements, Air, Earth, and Water, compelled into the muscular matter of an animal or the ligneous structure of a plant? May we draw from our modern science the conclusion that the fourth ancient element Fire—we mean thereby the empyreal forces which are gathered into the sunbeam—is the *creative* agency. "Where there is Light," said Lavoisier, "there we have organization and Life; where Light cannot penetrate, there death for ever holds his silent court."

The elementary constitution of matter, and the relations, so far as they are known, between Force and matter, are first considered by Mrs. Somerville. Then she examines all that has been done by spectrum analysis, as we believe, desiring to shadow out the influence of the radiant powers in determining organized forms. Our authoress then plunges (we can find no other word so truly expressive of the fact) into the microscopic structure of the vegetable world and of animal organisms. Here is the great defect of this work. There is no real connection between molecular science and microscopic investigation. The first examines with all the subtlety possible, by the aid of experimental induction, the phenomena dependent upon atmospheres of force enveloping the ultimate atoms of matter; the second observes the vast variety and the infinite beauty observable in the microscopic forms of life. But, although the microscope may teach the observer that a particular organic mass is but a wonderfully constituted aggregation of cells, that instrument can never advance him to a knowledge of the mechanical operation of the osmose forces by which the functions of life are carried on, nor to any appreciation of the value of the solar energies in producing an equivalent of organized form. It was a mistake, in the present state of science, to connect the two. Whatever may have been the first idea of the authoress, she must feel that the molecules have given her one set of links, and that the microscope has developed another. They may appear to have relations to each other; but a great many links are wanting, and we have two ends of a broken chain.

These volumes exhibit a remarkable amount of industry in the collection of facts. They show an equally remarkable clearness in the appreciation of the value of those facts, and they prove that the weight of years has fallen lightly upon the head of the lady who so long ago translated the Astronomy of Laplace, and examined so satisfactorily 'The Connection of the Physical Sciences.'

We were not honest if we allowed ourselves to be betrayed by our admiration for this lady into a false praise of her labours. These volumes are fragmentary: they are made up of the facts, and the fancies, of experimental and speculative philosophers. Neither the molecular science nor the microscopic observations of these volumes must be taken as reliable guides to the truth. They may be used with advantage as indicators of the world of wonders which is to be found in the infinitely minute; and there is a charm in the variety of the work which will render it valuable as a means of interesting young and intelligent minds in the study of Natural History.

A Course of Six Lectures on the Chemical Changes of Carbon. By William Odling, M.B., F.R.S., Fullerian Professor of Chemistry, Royal Institution. Reprinted from the 'Chemical News,' with Notes by William Crookes, F.R.S., &c. Longmans, Green, & Co., 1869.

For many years it was the custom of the late Professor Faraday to deliver, during the Christmas holidays, a course of lectures on some branch of science. These were professedly addressed to children; but the back seats and galleries of the lecture-theatre were generally crowded with adults, many of them well known in the scientific world, drawn thither by the charm of the great philosopher's eloquence and manipulative skill. During the many years that this custom was observed, almost every branch of physical science was thus expounded, and it must always be regarded as a misfortune that most of these lectures have passed away without a record. The last two courses which Faraday delivered, namely, those "On the Physical Forces," and "On the Chemical History of a Candle," were fortunately published by Mr. Crookes in the pages of the 'Chemical News,' the words as they fell from the speaker's lips having been taken down by a skilful shorthand writer.

For a few years Dr. Tyndall delivered the Christmas Lectures, and we are now glad to find that Dr. Odling, the worthy successor to Faraday in his chemical chair, has followed his predecessor's example in continuing them. As in the former cases, the course of lectures, taken down in shorthand, originally appeared in the 'Chemical News,' and they have now been reprinted from that journal in the form of a handsome volume of 162 pages, with preface and notes.

The author's arrangement of the subject is most logical, and the manner in which he starts from marble—a brittle solid—and gradually unfolds its chemical history before the audience, is a model for all lecturers on science. Dr. Odling starts with no assumption of knowledge on the part of his audience. Every step taken is the logical sequence of that which preceded it, and whilst explaining the phenomena with all that vivacity of style and clearness of expression for which the lecturer is so distinguished, he does not fail to supplement his explanation by a decisive experiment. He first shows that marble effervesces when an acid is poured on it, this effervescence being due to the liberation of a particular kind of air or gas. The same kind of air is then shown to be evolved from marble by the action of a red heat, quick-lime being left behind. The properties of lime are then shown; its evolution of heat when slaked by water; its non-effervescence on being treated with acids; its solubility in water; its combination with the air previously evolved from it to reproduce marble. These phenomena are illustrated with ample experimental evidence, until the audience are thoroughly familiar with the connection existing between quick-lime, marble, and the gas evolved from it. The properties of this gas are then explained; the extinction of ordinary flames in it, and its power to support the burning of other bodies are illustrated; but it is not until a piece of carbon is actually obtained before the audience by heating sodium in the gas which has just before been evolved from a piece of marble, that the lecturer makes use of the term carbonic gas, or leads any one to suspect that carbon in any form is associated with marble. Having proceeded so far, the lecturer shows how carbonic gas may be obtained in other ways; and the consideration of this subject naturally leads to the composition and properties of air and the subject of oxygen and oxides, the ordinary experiments with this gas being varied in a somewhat novel manner. These subjects occupy the first four lectures. The fifth is devoted to other forms of carbon, such as graphite and the diamond, and liquid and solid carbonic gas; whilst the concluding lecture treats of carbonic di-sulphide, carbonous oxide, and the unburning of carbonic gas by vegetation. From this part of the subject we are tempted to make one or two quotations, which will serve to show the clearness of expression with which Dr. Odling is so happily gifted. "If you reflect a little, I think you will come to this conclusion: that substances which grow—vegetable substances—are all of them destined ultimately to become burnt, or to undergo a change equivalent to burning. A great deal of wood, for instance, is chopped up and used for fire-wood; a great deal more is used for building ships, for forming the interior portions of houses, and making furniture. These ships and houses and furniture last for a certain time; they gradually pass from an honourable into a dishonourable condition; old furniture is put into the lumber-room; the disabled ships are broken up and destroyed; and at last they go to the fire, where the carbon becomes oxidized or converted into carbonic gas. But there is a great deal of vegetable matter which never undergoes this burning. In the autumn a large quantity of leaves fall to the earth, and there undergo some sort of change; this change is in fact a very slow burning, but without the phenomena of ignition which we see in the case of a fire, although the leaves are converted into carbonic gas or oxidized carbon. . . . . But a great quantity of vegetable substance neither undergoes burning nor decay, but is eaten. We know that cattle feed largely on corn and straw, and we ourselves consume much wheat and other grain. In these instances, although the vegetable substances do not, strictly speaking, *decay,* yet they undergo another form of the process of oxidation by which burnt charcoal is produced. . . . In this case, the carbon, instead of having been burnt in a furnace, has simply been burnt in our bodies, thereby rendering them warm, just as when it is burnt in the fire it warms a room."

Respecting the unburning of carbonic gas the author illustrates the phenomena of growth and vegetation in the following words, which, whilst they place this subject in a clearer light than we have ever before seen, show at the same time how intimately the conservation of force is bound up with the conservation of matter. "If the sun, instead of shining on the plants which grow on the earth's surface, were to shine entirely upon the stones, it would heat the atmosphere a great deal more than it does. As it is, a portion of the sun's heat disappears. What then becomes of it? It is absorbed by the vegetation. The amount of heat absorbed by a growing piece of wood in unburning the carbonic gas of the atmosphere into charcoal and oxygen is exactly the amount which the piece of wood is capable of giving out when its carbon is reburned in the air; and accordingly when we burn coals or wood or peat upon our fires, or consume bread and oil and wine in our bodies, and thereby produce a considerable amount of heat either in the fires or in our bodies, we are really manifesting once more in the form of heat, the sun's rays which years and years before shone upon the plants from which those substances were derived."

When we remind our readers that the chemistry of carbon includes the chemical history of all animal and vegetable substances, it is evident that there can be no better introduction to the study of that grand science for a youth whose tastes lie in that direction than the careful perusal of Dr. Odling's Lectures on the Changes of Carbon.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

A most instructive and suggestive paper "On the Condition of the Agricultural Labourer" appeared in a recent number of 'Fraser's Magazine.' The decennial statistical records of the Registrar-General and the annual agricultural tables issued by the Board of Trade are used in it with great ability to teach both the leading facts regarding the labourers in our fields, and their relations to the corresponding facts regarding the labourers in our mines and in our workshops. The main features of agricultural practice and experience in the several English counties are also cleverly marshalled, and exhibited so as to explain the distribution of the agricultural labourer over the country. The whole is not only discussed in a very well-written essay, but uncommonly well depicted and presented to the eye in diagrams and maps. In one set of curves, for example, the percentages (at the several ages) of the whole number of labourers employed on land and on coal and iron respectively are shown; and we see at a glance that a larger proportion of all that are so engaged is of the middle age in the cases of coal and iron than in the case of land. The curves of coal and iron labour stand higher between the ages of eighteen and forty-five; and the curve in the case of land labour stands highest over the early years and over the later years. The explanation is that many of the boys of the farm leave it for the workshop as they become men, and return to it as they approach old age and begin perhaps to look out for a maintenance at the expense of their parish. Other diagrams illustrate the quantity of agricultural labour employed per acre in the several counties; and it appears that it is not only the amount of arable land in a county which determines the quantity of agricultural labour employed per 100 acres,—that depends rather on the quantity of live stock which is on the land, and especially on the quantity of dairy stock. Lancashire and Middlesex employ more labour than other counties, notwithstanding their large proportion of grass land, no doubt because of the great quantity of live stock which their agriculture maintains. There is however a good deal of difference in this particular, also due to the character of the soil. Light lands are suitable for sheep farming, and sheep require but little care. On heavier soils cattle must be kept; and on arable land they must be kept in yards and stables, and this necessitates much labour. A portion of the essay is devoted to a discussion of the improvements in agriculture which are required in the interests of the labourer. We are not at all disposed to lament the decrease in the number of those employed in fields; which is the leading fact before reviewers of this subject. We may depend upon it that any tendency of this kind is the result of individual action on the part of those immediately concerned, which is prompted by the sharpest and most anxious insight into self-interest. If the sons of agricultural labourers are as a rule gradually leaving the country for the town, we should accept it not as a thing necessarily to be lamented and if possible prevented; but rather as a proof that the condition of the labourer in towns is declared to be better than that of the labourer in fields by that jury whose verdict, more than that of any other, is likely to be trustworthy. When it shall have become the interest of the farmer to employ more labour, and when he shall have been driven by the force of circumstances to pay a higher wage, then the course of events will alter; and we may possibly have hereafter to report that cottages and gardens, and education and wages in country places, are together offering attractions to the labouring man superior to those which are presented in the circumstances of our town population. There can be little doubt that when that happens, we shall have a longer lived and healthier race upon the whole than we have at present. That is an advantage affecting especially the very young, in which the town labourer is unquestionably at a great disadvantage.

The current number of the 'Journal of the Royal Agricultural Society' contains reports of several experimental researches, conducted by Dr. Voelcker into the effects of various manures on clover and grass. His observations on the clover under treatment, are that nitrate of soda is about as efficient in the production of growth as sulphate of ammonia—that common salt is variable in its effects, in one year producing growth and in another inefficient—that the heaviest crop is obtained from a mixture of superphosphate of lime and muriate of potash—that where salts of potash have been used the second cutting of clover weighs more than the second cutting of the unmanured crop, whereas when nitrate of soda has been used the second cutting is inferior. These are the results in the special instances reported; but every agricultural fact is the result of so many circumstances besides those to which the attention of a reporter is especially directed, that it is never safe to give to particular examples the value of a general law. In the case of ordinary grass-land, Dr. Voelcker found that the direct application of quicklime was injurious—that salt and quicklime produced no effect whatever—that mineral superphosphate and crude potash salts gave but a small increase of growth—that Peruvian guano yielded a large increase; and that the heaviest crop of grass, amounting to nearly twice the weight of that upon the unmanured plot, was obtained by a mixture of superphosphate and guano. The experiments were made in 1867, but the summer of 1868, when they were repeated, was so hot and dry, that no trustworthy results were then obtainable. It is plain that the effect of a very soluble manure like salts of potash or ammonia depends very much upon the circumstances of the application. If applied when the plants to be affected by it are in the condition of rapid growth, the result may be very great; while, if applied in winter when no immediate use could be made of them, it might be altogether washed to waste before the time of growth came round. Soluble top-dressings, therefore, ought to be applied at the commencement, or during the course, of the time of rapid spring growth, in order that their maximum effect may be obtained.

2. ARCHÆOLOGY (Pre-Historic),

And Notices of Recent Archæological Works.

The most important recent publication in connection with this branch of science is the grand work by Mr. James Fergusson, F.R.S., 'On Tree and Serpent Worship: or, Illustrations of Mythology and Art in India, in the First and Fourth Centuries after Christ; from the Sculptures of the Buddhist Topes at Sanchi and Amravati.' Published and prepared under authority of the Secretary of State for India in Council, this book enjoys the advantages of the printer's, engraver's, and photographer's skill, and justice is done in the ninety-nine quarto plates and twenty-one wood-engravings of these rare and beautiful remains of early Indian architecture so ably described by the author in the text. Mr. Fergusson traces out the origin, rise, and spread of the Buddhist religion in India, and the founding of monastic establishments for the reception of religious devotees, varying in size from those capable of containing two or three monks to several thousands.

The great interest about these edifices is that before the time of Asoko, 250 years before Christ, there was not in India a single scrap of a building worthy of the name. With the establishment of Buddhism, architecture first began to be manifested, and its very earliest and crudest designs can be traced in church caves, some of which are older than the Christian era. But probably the most interesting of all the Buddhist monuments are the topes or tumuli. These belong to two types,—the early period, represented by the Sanchi tope, in which one readily traces the imitation of the antecedent wooden constructions, carefully copied in stone and but little altered; and the latter period, by the Amravati tope, which from its beauty and elaborate workmanship clearly shows the development in architectural art which had taken place between their erection.

The Buddhist religion, like most forms of worship, became in process of time corrupted from its original purity and simplicity, and Mr. Fergusson traces in the sculpture upon these monuments the gradual introduction and ultimate adoption of tree and serpent worship with the religion of Buddha. This tree and serpent worship is found not alone in India, but appears to have prevailed in the world from the earliest times. The author traces in the account of the tree and serpent in the Book of Genesis a remnant of that old worship, and he shows how it had found its way among the Greeks and Romans, thence to Scandinavia, and every part of Europe. Tree and serpent worship prevails in Africa to a large extent, and there is even evidence of its existence in America.

The application of Architecture as an aid to Ethnology can hardly be too highly estimated, especially when the task of working out devolves upon so able and distinguished a scholar as Mr. Fergusson, and we hope that further researches may yield further results as worthy of publication as is the present volume.

The illustrations to this beautiful work must be seen and carefully studied, and they will be found well worth examination. An old Indian officer observed to the writer, "India is full of grand architectural monuments, but they all belong to the native races: if the English were driven out to-morrow, the only monument they would leave behind would be *empty bottles!*"

The appearance of two more parts* of Messrs. Lartet and Christy's *Reliquiæ Aquitanicæ* completes the description of the human and animal remains from the Cro-Magnon Cave. The human bones belonged to an old man, a woman of thirty-five or forty years of age, and an adult man. One of the old man's thigh-bones presents traces of an old wound, received possibly in a fight, and the skull of the woman had been penetrated through the left frontal bone, apparently by a blow from a stone axe, which seems to have caused death after about twenty days, as around the hole is a deposit of finely porous bony matter, which must have required fifteen to twenty days for its production.

These circumstances, coupled with the facial characters and the powerful muscular impressions on the limb-bones, stamp the Cro-Magnon people as a violent and a brutal race; but their brains do not lack size and good proportions, so that we may well infer from this fact and from their ingenuity in the fabrication of weapons, and the skill they displayed in their drawings of animals, that—savages as they undoubtedly were—they were no inferior race, but possessed of both physical strength and great ingenuity, which placed under more favourable conditions might have brought forth good results.

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* Parts viii. and ix.

One of the animals whose remains have been found in six or seven different localities in the caves of Central and Southern France, deserves special notice. It is that of the Saïga Antelope, now found living on the eastern slopes of the Ural Mountains and the shores and islands of the Sea of Azof. Strange to state, only the horncores have been found, yet their peculiar form convinced M. Lartet that his determination of these remains as belonging to the Saïga was correct.

He suggests that the long, solid, and pointed horns of the Saïga, so well adapted to make formidable weapons, may have been obtained as articles of barter from a more eastern people, with whom this antelope was indigenous. Numerous plates (accompanied by descriptions) of stone implements and Reindeer-horns carved and perforated, for use or ornament, increase the interest of this work, a lasting memorial of our much-lamented countryman Henry Christy.

A cromlech in Jersey, recently opened, was found to contain, besides broken pottery, nine urns, osseous remains, charred wood, and ashes, a stone amulet (drilled with two holes), and a few flint flakes. Several ancient bronze wedges were picked up near the same spot.

Mr. J. W. Flower read a paper before the Geological Society, on 28th April, "On the Distribution of Flint Implements in the Drift, with reference to some recent Discoveries in Norfolk and Suffolk." Mr. Flower suggested that the implements belonged to a period antecedent to the true River-gravels, when the valleys of the little Ouse and other tributary streams were tidal: to this Messrs. Prestwich, Ramsay, and Evans demur, holding that all the gravels with flint implements are of fluviatile origin. Mr. Searles V. Wood, jun., however, to a certain extent supports the view taken by Mr. Flower, and considers a part of these gravels at least to be due to tidal action. Mr. T. C. Wallbridge, at the same meeting, mentioned (in a paper "On the Geology of Hastings County, Canada West") that in a deposit of Hæmatite, called the "Kane Ore-bed," ancient workings were discovered—apparently those of Indians, who may have used the ochre for war-paint. He met with bone needles and other objects of human workmanship, which he exhibited.

ETHNOLOGICAL SOCIETY.

Part I. of the new Quarterly Journal of this Society made its appearance in April last, edited by Professor Huxley, F.R.S. (the President), and a Committee of the leading members of the Society. The number contains articles by (1) Col. A. Lane Fox, Hon. Sec. E.S., "On some Flint Implements found associated with Roman Remains in Oxfordshire and the Isle of Thanet," tending to prove that there must have existed, during the Roman period in this country, a class of people who employed flint tools such as we are in the habit of associating with a very early condition of human culture. The interblending of civilized and barbarous conditions in Romano-British times occurred as certainly as it does in South America at the present day, where every shade of gradation may be observed between the highest condition of civilized life and that of savages armed with bows and poisoned arrows and wearing lip-stones. In the Gold-ornament Room at the British Museum may be seen an Etruscan necklace of most elegant workmanship in gold, from which is suspended a flint arrow-head of the same pattern as one of those figured by Col. Lane Fox from Oxfordshire.

(2.) Mr. H. Howorth gives Part I. of an "Essay on the Westerly Drifting of the Nomads from the Fifth to the Nineteenth Century," in which he traces the immigration and spread of the various nomade races which have overspread the great plains and steppes of Southern Russia and Poland, and the plains of Hungary, Persia, and Asia Minor.

(3.) Col. A. Lane Fox gives an account of a bronze spear with a gold ferule and a shaft of bog-oak, 6 feet 1 inch in length, the bronze head 1 foot 4 inches from the point to the base of the socket, obtained from Lough Gur, County Limerick.

(4.) Mr. Hyde Clarke contributes a paper "On the Proto-Ethnic Condition of Asia Minor," and traces out the early history of the Khalubes and other hill-tribes engaged in mining and smelting ores, and endeavours to correlate them with the Yuruks inhabiting the mountains of Western Asia Minor at the present day.

(5.) Sir John Lubbock's account of some stone flakes of a very rude description, from the Great Flat between Table and False Bays, Cape of Good Hope, is interesting from the fact that, although the African races are almost all in a very barbarous state so far as relates to social conditions, yet a knowledge of rude metallurgy has been long and widely spread throughout Africa, and we know, as yet, scarcely anything about the stone implements which, no doubt, here, as elsewhere, preceded the use of metals.

(6.) Mr. H. M. Westropp's paper "On Cromlechs and Megalithic Structures" is an endeavour to prove that such archaic remains are peculiar to no people or race or country, but are the result of an endeavour to secure a permanent place of sepulture by a people in a rude and primitive state of civilization. To this conclusion Col. Lane Fox demurs, and in a very able criticism shows, first, that the megalithic monuments are peculiar to certain regions, as Ireland, Britain, Denmark, Sweden, Normandy, the South of Spain, the North of Africa, India, &c.; and secondly, that they had many other uses besides that of marking and commemorating the interment of the dead; such as, for instance, places of assembly and council meetings, of judgment, of worship (not connected with the dead). Col. Fox instances the frequent interment in sacred edifices at the present day as a case in point to prove that the worship of the dead may have had no actual connection with the stone circle, although the dead may be buried within its radius.

(7.) Dr. Hooker contributes some interesting notes on Child-bearing among the Aborigines in Australia and New Zealand.

(8.) Mr. Layland's notice of the Cave-cannibals of South Africa has too much of the "Traveller's Tales" look about it. Speaking of one old savage, he says he had "a 'devilled kidney' or 'boiled missionary' look about him." Such remarks are hardly in accord with a scientific journal.

Mr. J. H. Lamprey, the Assistant-secretary and Sub-editor to the Society, suggests an ingenious method by which photographs of natives, taken in distant countries, may be rendered of greater value for purposes of comparison and study. The subject to be photographed is placed against a background formed by a frame of wood, 7 × 3 feet, neatly divided by strained threads of silk into 2-inch squares, thus giving an index-scale for the entire figure easily applied to any subject.

Many minor papers, notices, and reviews are contained in this number of the Journal. It starts well at least: let us hope its succeeding numbers may prove equally worthy of notice.

ANTHROPOLOGICAL SOCIETY.

Many of the papers read before this Society, and published in their Journal, are of a metaphysical or physiological character.

Dr. James Hunt communicates a paper "On the Character of the Voice in the Nations of Asia and Africa, as contrasted with that in the Nations of Europe."

Dr. John Beddoe, Pres. A.S.L., gives the result of personal observations on the physical characteristics of the people of Brittany.

Dr. Charnock, Vice-President, describes a menhir or dolmen lying broken on the ground at Locmariaker, in Brittany, which, when erect, must have measured 72½ feet.

Mr. A. L. Lewis, who also describes the same place, adds an account of Gavr Inis, or Goat's Island, situated in the Morbihan

Sea, and celebrated for its chambered tumulus, the chamber and gallery of which are together about 70 feet long, 5 feet high, and 3 feet wide at the entrance, increasing gradually to a height and width of from 6 to 8 feet. The surfaces of the upright stones forming the walls are nearly all covered with incised ornamentations, composed chiefly of segments of circles interspersed with wavy lines, resembling somewhat the Northumbrian rock-inscriptions and those of the tumulus of New Grange, Ireland.

Dr. Hunt reports the results of an investigation of the megalithic monument of Carnac, in Brittany, controverting the statement of Sir John Lubbock that Avebury and Stonehenge were the two largest monuments of their class in Europe, and insisting on the superior proportions of Carnac, which also differs in many respects from Stonehenge. Dr. Hunt denies that there is any proof of the contemporaneity in construction of Carnac, Avebury, and Stonehenge.

Mr. L. Owen Pike contributes a singular paper "On the alleged Influence of Race upon Religion," in which the author expressed his conviction that any race might, to all appearance, hold any creed, and, in conclusion, that, although there may exist certain race-elements in the religion of every people, they are of minor importance, and cannot be defined in the present condition of language and psychology!

Dr. John Davy, F.R.S., gives a paper on the Negro, chiefly in relation to industrial habits, vindicating the negro race against the unjust charge of being inveterate sluggards.

Dr. Charnock, F.S.A., describes the peoples of Transylvania, which country embraces no less than fourteen distinct races, a most interesting region to the Anthropologist.

Mr. H. Westropp, "On the Mythic Age," attempts to show the intellectual unity of the human race from the almost universal prevalence of similar myths among early and uncivilized peoples in remote countries.

Mr. G. Harris, F.S.A., attempts the difficult task of explaining "the Mental and Moral Distinctions occasioned by Difference in Sex," and Mr. J. McGrigor Allan the equally daring attempt to show "the Real Differences in the Minds of Men and Women." The former writer honestly observes that there are extensive differences which no artificial attempts can lessen; but each sex has its proper sphere of exertion and duty in which it excels. The latter writer evidently places women on a very much lower physical and moral platform than man, and whilst charging women with contending for empire and seeking masculine privileges, uses rather unfair arguments. Some of his assertions are palpably inaccurate, as, for example, that "women are *always* more or less invalids."

3. ASTRONOMY.

(Including the Proceedings of the Astronomical Society.)

After the failure of Brorsen's comet to make its appearance at the appointed time, astronomers may think themselves fortunate in the re-discovery of Winnecke's short-period comet at its present return to perihelion. M. Winnecke himself re-discovered the comet at Karlsruhe. He describes it as large, but not bright. By the time these lines appear it will have become concealed from view through its proximity to the sun. We do not hear that any observations of importance have been made upon it, nor had Mr. Huggins, at the time of the last meeting of the Royal Astronomical Society, been able to apply spectroscopic analysis to this object.

M. Faye having called in question Mr. Stone's title to the merit of being the first to exhibit the cause of the errors which had resulted from Encke's treatment of the transit observations in 1769, Mr. Stone has put forward a masterly defence of his position. If any doubts could have remained of the imperfectness of M. Powalky's treatment of the subject—which M. Faye has undertaken to defend—Mr. Stone's paper would have conclusively removed them. He shows that M. Powalky has followed no settled rule in interpreting observations, that he has rejected good observations without any cause, and some observations for no other reason than their incompatibility with the general run of the discussion. Mr. Stone particularly cites the ten available observations of duration. All of these are used by him, and perfectly represented in his result; whereas M. Powalky has fully employed only four, to three of which, taken in combination, he has given the weight of one only. The whole paper is not only most interesting and valuable, but satisfactory as fully establishing the claim of our distinguished fellow-countryman to the honour of having removed what had long been looked upon as a stain on "the most exact of the sciences." If there is any objection to be made against Mr. Stone's defence of his case, it is that here and there it seems to be in the slightest degree too personal. In scientific discussions as in scientific observations, "personality" should be reduced to a minimum. It is, however, not to be wondered at that Mr. Stone should object to remarks which seemed calculated to diminish the value of his researches on the transit-observations of 1769.

For the next few months Saturn will be an interesting object of observation. His rings are now nearly at their widest expansion, and will doubtless be carefully examined by astronomers for any signs of those processes of change which are suspected to be in progress. Towards the end of the quarter Jupiter will also be well situated for observation. Venus and Mars will be evening stars throughout the quarter, but the latter is getting too far off for effective observation.

PROCEEDINGS OF THE ASTRONOMICAL SOCIETY.

Mr. De la Rue had called attention to the great changes which appeared to have taken place in the figure of a great solar prominence visible during the total eclipse of August, 1868. These changes appeared to suggest that the prominence had undergone an axial rotation during the period occupied by the moon's shadow in travelling from Aden to Guntoor. It now appears, however, that the engraving of the Aden photograph in the 'Engineer,' on the accuracy of which Mr. De la Rue had founded his opinion, was incorrectly designed. Mr. De la Rue has obtained a copy of the original photograph, and he finds that the hypothesis of a marked change having taken place must be abandoned. Instead of the Great Horn being so curved that its point was directed in the opposite direction from that in which it was turned when seen at Guntoor, the aspect of the prominence in the two pictures is almost identical. It requires actual measurement to distinguish any change of position. Mr. De la Rue considers, however, that the evidence is sufficiently distinct to enable us to conclude that some change had occurred in the direction of the great prominence during the forty minutes which elapsed between the Aden and Guntoor observations; but it is impossible to say whether this was due to an axial rotation of the prominences.

In a paper on the late transit of Mercury, by Mr. Abbott, there occur some remarks about the geographical position of Australian towns, which are interesting in connection with the approaching transit of Venus. The longitude of Hobart Town appears to have been well determined, but not with such accuracy as will be required for the application of Delisle's method to the determination of the solar parallax. Captain Kay agrees with the Astronomer Royal in considering that the Australian colonies are unsuited for observing the transit of Venus until better known. Mr. Ellery, on the other hand, thinks differently, and considers that the position of the Melbourne Observatory is as well known as that of the Cape of Good Hope Observatory.

A paper by Mr. Mann on the subject of the same transit contains an elaborate discussion of the observations which were made at the Cape of Good Hope, and cannot fail to be highly valuable to astronomers who may in future times undertake the formation of new tables of Mercury. It will be remembered that in England the whole transit of Mercury was not visible. Mr. Mann was able to employ observations made by Sir T. and Mr. G. Maclear from the passage of Mercury's centre across the sun's limb at ingress until exterior contact at egress. The result of the examination of twenty-two observations is as follows:—

Correction to excess of Sun's R.A. over Mercury's $= -0''\cdot92 - \cdot092\,\tau$;
" " N.P.D. " $= -0''\cdot16 - \cdot043\,\tau$;

where τ is the assumed error in the determination of the longitude of the Cape of Good Hope Observatory. The observations were made with the 8½-foot equatorial. Sir T. Maclear adds some remarks on the observed diameter of Mercury. He deduces from all the observations the value $8''\cdot376$, with a probable error of $\pm 0''\cdot11$. This result is less than the tabular diameter by $1''\cdot50$. As the apparent diameter of Mercury is increased through the effects of irradiation when the planet is observed off the disc of the sun, and diminished through the same cause when the planet is in transit, the difference is readily explicable.

The Astronomer Royal comments on M. Puiseux's statement that Halley's method can be applied with advantage to the transit of 1874. He interprets M. Puiseux's carefully-worded statement to signify that in the French mathematician's opinion Halley's method is better than Delisle's. We do not find in M. Puiseux's paper any passage which can be so understood. All that Puiseux has said is in one place that the message can be applied "advantageously," and in another that "there can be no reason why it should not be applied." It would be to exaggerate the requirements of courtesy in scientific discussion to assume that M. Puiseux had really another meaning, but was prevented by courtesy from expressing it. Nor will his figures bear such an interpretation. He points to statistics which give intervals somewhat greater than those which come out by Delisle's method; but so skilful a mathematician could not but be aware that Halley's mode involves four observations of contact, Delisle's only two; and that consequently more had to be considered in forming a comparison between their relative advantages than the mere length of the intervals involved. The careful perusal of M. Puiseux's pamphlet suggests the impression that what he really had in his mind in indicating a difference of opinion with the Astronomer Royal was the latter's statement that Halley's method "fails totally" in 1874. The concluding sentence of Mr. Airy's note indicates a change of opinion on this point. After expressing his wish that Halley's method may be applied to the transit as well as Delisle's, he adds, "Every series of observations which can really be brought to bear upon this important determination will be valuable."

Mr. Stone supplies an interesting paper on a "personality" in the determination of the line of collimation of a transit instrument. The existence of a personal error of this sort to an appreciable amount would be difficult to deal with, and would cast a certain amount of doubt over the whole of the instrumental corrections. By comparing together the observations made at Greenwich by Messrs. Dunkin, Ellis, Creswick, and J. Carpenter, Mr. Stone has discovered that a real personality exists, but it is so small, that, as far as Greenwich observations are concerned, the uncertainties introduced into collimation-determinations may be neglected as insignificant.

Mr. Browning describes a remarkable train of sun-spots, visible on the 7th of March. He attempted to observe them with the full aperture of his fine 12-inch silvered-glass reflector, but the definition was so bad, owing to the state of the atmosphere, that he had to reduce the aperture to 6 inches. He then introduced what is called a solar plane, that is, a plate of parallel glass silvered on the exposed side, into the mouth of the telescope. The spots thus observed presented the appearance of an almost continuous penumbra, in an irregular hollow curved line, with umbræ at intervals; some of the umbræ containing blacker nuclei. On the convex side a portion of the penumbræ assumed the form of a pair of compasses. He found the outside dimensions of the cluster to be from E. to W. 97,700 miles, and from N. to S. 27,130 miles. The group was the largest which had appeared during the recent outbreak. The direction of its length was almost exactly parallel to the sun's equator. A remarkable circumstance attended the approach of the spots to the edge of the sun's disc; the faculous matter around the spots became gradually brighter and brighter, until, when the spots had reached the limb, it quite obliterated the penumbra. The black spots were then seen surrounded by a white border; a distinct proof, if any were needed, that the faculæ are above the solar surface.

Mr. Browning also describes an improved method of mounting finders. Every observer is aware of the inconveniences which result from the imperfect plans at present used for adjusting finders. Mr. Browning proposes a remarkably promising plan, so simple in its details, that the wonder is it has never been used before. In place of the two rings, each with three adjustment-screws, the only arrangement hitherto applied to a movable finder, Mr. Browning has the finder attached to two uprights. Its attachment to the one nearest the eye-piece is so arranged that the finder can be shifted round a horizontal axis perpendicular to the axis of the telescope; the attachment to the other permits of motion round a vertical axis (the telescope being understood, for the purposes of this description, to be placed in a horizontal position). It is the more necessary that a simple mode of adjusting finders should be made use of, because in spectroscopic observations the star or other object under examination must be brought exactly between the jaws of the spectroscopic-slit, or the spectrum will not be visible.

Mr. Proctor supplies the elements of his recalculation of the rotation of Mars. The total period taken into account contains 640,284,123 seconds, corresponding to 72,232 rotations of the planet, and giving a rotation-period of 24 h. 37 m. 22·736 s. He remarks that Kaiser's period (24 h. 37 m. 22·625 s.) would throw the Kaiser sea so far from the centre of the disc at the epoch of Hooke's observation, that that feature would have been concealed from view by the haze which always hides the planet's line. Hooke's picture shows the Kaiser sea only 18° from the centre of the disc. On the other hand, Kaiser's estimate, hitherto undoubtedly the most exact, suffices to show that it *was* the Kaiser sea, and not the somewhat similar Dawes' strait, that Hooke saw; for the latter, according to Kaiser's period, must have been on the farther side of the planet at the time of Hooke's observation. The period given by MM. Beer and Mädler (24 h. 37 m. 23·8 s.), on the other hand, although accounting for Hooke's observation on the omission of a complete rotation, is shown by Sir W. Herschel's drawings to be incorrect. It is a matter of some interest thus to be able to assign the exact period of a planet's rotation. As our earth's motion of rotation is slowly diminishing through the moon's action, it may be important, at some far distant epoch, to have in Mars a cosmical clock of undoubted accuracy. For the comparative smallness of Mars, his greater distance from the sun, the smaller proportion which the seas on his surface bear to the continents, and the fact that he has no satellite, all encourage the belief that his period of rotation cannot be affected appreciably by the motion of a tidal wave, as is the case with the earth.

A paper by Mr. Maclear on the subject of the Meteoric shower of November, 1868, is chiefly remarkable for the evidence it supplies of the wide range over which the display of last November was to be seen. We have already had accounts of the shower as seen in America; it was well seen in England; and it now appears that it was seen under favourable circumstances at the Cape of Good Hope. This suffices to show that the part of the meteor system traversed last November differs wholly in character from that which gave birth to the more brilliant, but much more short-lived display of November, 1866.

Professor Cayley gives a simple proof of the property, that if an indefinitely thin shell of uniform density, rounded by two similar and similarly situated ellipsoids, attract a point P on its outer surface, the attraction (assumed to act in the direction of the normal) is equal to twice the attraction of an infinite plate, the thickness of which is equal to the normal thickness of the shell at the point P. The proof may be thus summarized:—

Let a cone, having its vertex at P, circumscribe the interior ellipsoid. All the mass of the shell outside this cone may be neglected when the shell is supposed indefinitely thin. Of the part within, it will be obvious, on consideration, that the two portions separated by the circle in which the cone and the inner ellipsoid touch each other, attract P equally. The portion nearer to P may be divided into two, by a plane touching the inner ellipsoid, when the normal through P meets it, and of these parts only the one next to P need be considered, the attraction of the other vanishing in respect to that of this part. Thus, finally, we get the attraction on P equal to twice that of a cone having P as vertex, and inscribed within the shell, so that its base touches the inner ellipsoid. In the limit, the vertical angle of this cone becomes equal to two right angles, and the attraction of the cone becomes that of an infinite plane, whose thickness is equal to the normal thickness of the shell at P.

The same eminent mathematician gives a remarkably simple explanation of Gauss's solution of the problem of determining a planet's orbit, from three observations. We must refer those of our readers who are interested in this problem (selected by the Cambridge University as the subject of the Adams' Prize Essay), to the paper itself, as it would be wholly impossible either to abbreviate Professor Cayley's treatment of the question or to give the whole of it in these pages.

Mr. Dunkin gives another of those interesting papers on personality in observation, which have recently been founded by the Greenwich observers on the immense amount of valuable material available to them for the purpose. The object of the present paper is a personality in observing transits of the moon's limb. It has been described by the Astronomer Royal as, strictly speaking, a difference between the personal equation for the moon and that for the stars; the duration of the impression on the nerves of the eye not being the same when the moon is observed as when a star is. The effect of the personality is visible more in the tabular errors in the first half of the lunation than in the second, but the differences of each observer's mean from the mean of all are too small to enable one to trace the personality to any particular source. An important result of the investigation is the evidence it affords of the necessity of intermixing observers, when absolute places have to be determined.

Mr. Kincaid describes a driving-clock founded on hydraulic principles. The contrivance would need trial, we should imagine, before its actual qualities can be pronounced upon. Theoretically it is excellent.

4. BOTANY—VEGETABLE PHYSIOLOGY AND MORPHOLOGY; AND RECENT LITERATURE.

Aster salignus.—We some time since noted the discovery of this plant by Mr. Hiern, of St. John's College, near Cambridge. Two ladies—Miss Bever and Miss Edmonds—announce its occurrence on the shores of Derwentwater. Besides in Cambridge, this plant also occurs in several places on the banks of the Tay, between Dalguise and Seggieden. In one locality below Perth, Dr. White remarks that it is associated with several introduced plants, such as *Linaria repens*, *Petasites alba*, *Sanguisorba Canadensis*, *Mimulus luteus*, *Crocus vernus*, and *Narcissus pseudo-narcissus*, which are all common, more or less, and established along the banks of the river. In France, *Aster novi Belgii* seems to hold the same place as *A. salignus* does in Britain—that of an exotic plant, well established on the banks of several rivers, as near Strasbourg, Langres, and Lyons.

A Method of Bleaching Wood Pulp.—M. Ouvli, a French chemist, states that chloride of lime is open to this objection in the process of pulp-bleaching for the purposes of paper manufactories, *viz.* that if at all in excess, it gives a yellow colour to the pulp. Powerful acids also, without exception, tend to give a reddish tinge to the paper when exposed for a long time to the action of sun or moisture (whence the colour of many foreign papers in books), and the least trace of iron is sufficient in a very short time to blacken the pulp. M. Ouvli says he has succeeded in avoiding all these inconveniences by the use of the following mixture. For a hundred-weight of wood-pulp, 400 grammes ($\frac{4}{5}$ths of a pound) of oxalic acid are taken; this has the double advantage of bleaching the colouring matter already oxidized, and of neutralizing the alkaline principles which favour such oxidation. To the oxalic acid one pound or a little more of sulphate of alumina is added, entirely deprived of iron. The principal agent in this mode of bleaching is the oxalic acid, the power of which over vegetable colouring matters is well known. The alum has no bleaching power of its own, but forms with the colouring matter of the wood an almost colourless "lake," which has the effect of increasing the brilliancy of the pulp.

Curvature in Plants.—M. Ed. Prillieux has studied this subject in a very detailed manner—experiments both on plants and on imitative models having been extensively made. He arrives at the conclusion that a purely mechanical cause must be attributed to the curvature produced by shocks and vibrations on buds, contrary to general opinion, which had considered these phenomena as of a very different character and peculiar to living beings (whereas

M. Prillieux produced the same results in a model). A certain state of the tissues is indispensable to their manifestation; they can only be produced at that period of development when the tissues are sufficiently flexible; but it is, nevertheless, undeniably true that they are due to a physical cause.

The Sleep of Plants.—In an exhaustive essay on this curious subject, of much physiological importance, M. Royer reviews the opinions of those who have written on the question, and adduces a great number of facts in illustration of the various causes which produce the sleep of leaves and of flowers. These, he maintains, are not quite identical. He distinguishes a diurnal sleep as well as a nocturnal for plants equally with animals. Heat, light, and turgescence, are influential in affecting the sleep of leaves—only heat and turgescence in the sleep of the corolla—by their excess or diminution. Flowers when they sleep assume the form of their characteristic æstivation, just as many animals assume the position they occupied *in utero*. The inclination of flowers to the sun depends on the peduncle, not on the flower at all.

Excretion of Carbonic Acid by Plants.—Mr. Broughton, Chemist to the Cinchona Plantations of the Madras Government, has made, with a Sprengel's air-pump, some important observations as to the exhalation of CO_2 by plants—a phenomenon which was well known to occur in the night. The experiments were made mostly on cut portions of the plants, but experiments were also made for control on plants as they actually grow. Sometimes the deprivation of oxygen was effected by substituting for air an atmosphere of hydrogen or nitrogen; whilst comparative experiments were made on plants supplied with air that had been freed from carbonic acid. The main conclusions to which he was led are enunciated by the author as follows:*—

1st. That nearly all parts of growing plants evolve carbonic acid in considerable quantities, quite independent of direct oxidation.

2nd. That this evolution is connected with the life of the plant.

3rd. That it is due to two causes, namely, to previous oxidation, resulting, after a lapse of time, in the production of carbonic acid, and to the separation of carbonic acid from the proximate principles of the plant while undergoing the chemical changes incident to plant-growth.

The Respiration of Aquatic Plants in Darkness.—M. Deherain has pointed out that when aquatic plants are kept in darkness they are literally asphyxiated; for on making examination of the water in which they have died, he has found absolutely no trace of oxygen, but only carbonic acid and nitrogen. In a pond where a very dense growth of *Lemna minor* had been allowed to accumulate on the surface, a sudden death of all the fish in the water occurred, and the smell of sulphuretted hydrogen was remarkably strong. On making examination of the water by careful chemical analysis, M. Deherain found that there was absolutely no dissolved oxygen present, hence the death of the fish. The aquatic plants had been killed by the exclusion of light caused by the Lemna growth, and they had absorbed what oxygen was available. M. Van Tieghem, a very distinguished French botanist, relates some interesting experiments on the action of light in the respiration of aquatic plants. He maintains that the chlorophyl is brought into a condition comparable to that of a *phosphorescent* body by the action of direct sunlight. It is direct sunlight only which is competent to *start* the decomposition of carbonic acid by the chlorophyl—as numerous experiments prove,—diffused (polarized) sunlight not having that power: when withdrawn from direct sunlight and kept in the dark, Van Tieghem observed that the plant still continued to exert chemical action for *three* hours, and for *nine* hours if kept in diffused daylight instead of darkness. From this he concludes that the vibrations induced by the chemical rays of sunlight are continued in the chlorophyl after removal from their contact, which is indicated by the continued chemical action, just as light is continued by the sulphides of barium, &c.; and he supposes that diffused daylight, though incompetent to *start* this action, can assist in continuing it.

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* 'Proceedings Royal Society,' April 29th.

The Action of the Cuticle in the Respiration of Plants.—M. Barthélemy has applied the results of Graham's researches on dialysis of gases through colloid membranes to the case of plant-respiration. In plants there exists a cuticle which has a chemical composition and a physical constitution like caoutchouc. It is wanting at the "stomata" which occur on the under-surface of leaves. The experiments of many observers, notably Boussingault, have shown that the exhalation of oxygen is greatest when sunlight falls on the *upper* surface of leaves. M. Barthélemy explains this by supposing the respiration to take place *through* the cuticle, the stomata perhaps absorbing nitrogen. The relative permeability of caoutchouc to various gases agrees well with the hypothesis—carbonic acid passing most freely, oxygen also freely, and nitrogen with difficulty. This view is further supported by ingenious experiments, in which *leaves* were substituted for caoutchouc in experiments similar to Mr. Graham's, and very fairly concordant results were attained.

Cephalodia of Lichens.—Dr. Nylander makes some important observations on these organs, which were but little known before he pointed out their importance as furnishing a primary anatomical character in their gonimia. They occur only in thalli which have gonidia. He distinguishes three principal kinds:—1. Epigenous, which are the most frequent; 2. Hypogenous, known only in *Peltidea* and *Psoroma*; 3. Endogenous, or Pyrenoid, which occur in foliaceous lichens. Recently Dr. Nylander has detected both epigenous and hypogenous cephalodia in *Lecanora araneosa* from New Zealand.

Mr. Lauder Lindsay treats of a very interesting matter relating to Lichens—*viz.* those species parasitic on other lichens—in the 'Quarterly Journal of Microscopical Science.'

A New Mode of Preserving Fungi.—Mr. James English has hit on a very effective method of preparing Fungi for the herbarium, and has communicated a paper on the subject to the Botanical Society of Edinburgh. By *waxing* the specimens which it is desired to preserve, the natural pileus and stipe are retained. Specimens treated in this manner in 1866 are now as fresh as when first prepared, and a series of fungi, treated in this manner by Mr. English, are now in the Museum of the Botanical Society of Edinburgh.

New Diatoms from the Arran Islands, Galway.—The Rev. Eugene O'Meara describes and figures in the 'Quarterly Journal of Microscopical Science' more new Diatoms from dredgings off the west coast of Ireland. The species are:—*Pleurosigma giganteum*, var. *baccatum*, *Plagiogramma costatum*, *Melosira Wrightii*, *Pinnularia marginata*, *Pinnularia scutellum*, and *Amphiprora costata*.

Botanical Appointment.—Dr. Henry Trimen, of King's College, London, Lecturer on Botany at St. Mary's Hospital Medical School, has been appointed an assistant in the Botanical Department of the British Museum. Those who know the vast accumulation of unworked material at the Museum will rejoice that an additional office has been created, and that so able a gentleman as Dr. Trimen has been chosen to fill it.

5. CHEMISTRY.

At the soirée of the Royal Society, on March 6th, Mr. H. C. Sorby, F.R.S., exhibited for the first time some phenomena in his spectrum microscope, which have led him to the conclusion that they are due to the presence of a new element, for which he has proposed the name of jargonium.

Mr. Sorby describes jargonia as being an earth closely allied to zirconia, existing in small quantity in zircons from various localities, but constituting the chief ingredient of some of the jargons from Ceylon. It is, however, distinguished from zirconia and all other known elementary substances by the following very remarkable properties. The natural silicate is almost, if not quite, colourless, and yet it gives a spectrum which shows above a dozen narrow black lines, much more distinct than even those characteristic of salts of didymium. When melted with borax it gives a glassy bead, clear and colourless both hot and cold, and no trace of absorption bands can be seen in the spectrum; but if the borax bead be saturated at a high temperature, and flamed so that it may be filled with crystals of borate of jargonia, the spectrum shows four distinct absorption bands, unlike those due to any other known substance. Further researches have shown Mr. Sorby that jargonia exists in two distinct conditions, which have different specific gravities and optical properties. The flamed borax beads give two entirely different spectra, according to the temperature to which the enclosed crystals have been exposed, and there is an analogous difference in the silicates. On taking a pale-green jargon, which naturally showed a mere faint trace of the absorption bands, and keeping it at a bright red heat for some time, the specific gravity gradually increased from 4·20 to 4·52, and the spectrum then showed all the narrow black absorption bands in great perfection. It appears, however, that Professor A. H. Church, M.A., published a similar discovery nearly three years ago in the 'Intellectual Observer.' Not only did he describe bands, but he noticed their occurrence in the spectra of some stones from particular localities, and their absence from stones from other localities. He also added his views as to the cause of these bands—the presence of an element in some specimens, not found in others. An account of Mr. Sorby's further discoveries in spectrum and microscopic analysis will be found elsewhere.

During an examination of the Heaton process for making steel at Langley Mill, Mr. Crookes has noticed a remarkable instance of the crystallization of iron. When the violence of the action between the molten iron and the nitrate of soda has subsided, the lower portion of the apparatus, called the converter, is detached, and after a few minutes the contents are turned out on to the floor in the form of a porous mass of nearly ¾ of a ton in weight. Upon examining portions of this metallic sponge, it is found to consist of a segregation of minute feathery crystals of iron, apparently built up of small cubes. The outlines of some of these are perfectly sharp, and their appearance, especially in the cavities, is very beautiful.

In February, 1868, two Belgian chemists—MM. Graebe and Liebermann—communicated a memoir on alizarine, from which an intimate relation was acknowledged between this colouring matter and anthracene. By heating alizarine with zinc dust, they obtained as the sole product of reduction a hydrocarbon having all the qualities of anthracene. Having thus obtained anthracene as a product of alizarine, MM. Graebe and Liebermann have since succeeded in solving the inverse problem, that is to say, the artificial preparation of alizarine by means of anthracene. They convert that hydrocarbon into alcohol, and the alcohol into an acid (lizaric acid and alizarine being synonymous), by acting upon the hydrocarbon with chlorine or bromine, and next effecting a double decomposition by means of acetate of potassa and caustic potassa; after which an oxidizing agent is again made to act upon the alcohol so obtained. The properties of the product, as well as the colours which it has given on mordaunted cotton, prove the complete identity of artificial alizarine with that from madder root.

Professor G. Hinrichs has described the following ingenious way of preserving sodium untarnished as a lecture specimen.—Take two test-tubes, one a little smaller than the other, so as to slip into the latter without leaving much space between the two glass walls; put some carefully-cleaned sodium in the wider tube, insert the more narrow tube, having previously given a thin coating of beeswax to the upper part of this latter, then gently heat the whole on a sand-bath. The sodium will fuse, and by a gentle pressure, the inner tube is pressed down, so as to force the fused metal over a large surface between the two tubes, while the air is totally excluded by the beeswax. Sodium has been kept for more than six months in this way as bright and brilliant as when first put up.

It is well known that hydrochloric acid is used for the purposes of dissolving the earthy salts of bones, in order to obtain the gelatine they contain in such a state as to render that substance readily soluble in boiling water. The use, however, of hydrochloric acid is rendered rather inconvenient for this purpose, on account of the formation of chloride of calcium, which interferes with the drying of the gelatine. M. Coignet, at Paris, has found that sulphurous acid answers the purpose of hydrochloric acid in this instance perfectly well. The bones are placed in cold water, and through the water a current of sulphurous acid gas is forced, so long as is required to completely soften the bones, which are afterwards washed in fresh water wherein some sulphurous acid gas has been previously dissolved.

Professor Horsford, of Yale College, has tried to detect fluorine in the human brain; he was induced to do so by the fact that fluorine so frequently accompanies phosphoric acid in the mineral kingdom, and also on account of the large proportion of phosphoric acid found in the brain and nerves by Von Bibra and others. After having very carefully ascertained that the reagents he was about to apply were quite free from fluorine, the learned professor operated upon a human brain which had been long kept in spirits of wine, but which in consequence of neglect had, by the evaporation of the liquor, become wrinkled up and dry. As a result of a series of carefully-made experiments, he has proved undoubtedly the existence of fluorine in the brain.

From some experiments made by Professor Bloxam, of King's College, it appears that a mixture of tincture of guaiacum and ozonized ether (that is to say, a solution of peroxide of hydrogen in ether) instantly produces, with blood or bloodstains, a beautiful blue tint. Professor Bloxam mentioned that in the case of a bloodstain twenty years old, he had extracted a single linen fibre with an almost inappreciable amount of stain on it; and had found the characteristic blue colour was immediately induced by the test, and readily detected by microscopical examination.

It is a well-known fact that iron is dissolved by molten zinc, but nowhere is any definite alloy of these metals described, nor yet is it stated how much iron is dissolved by zinc. Dr. Oudemans, jun., obtained for analysis a piece of alloy which had been formed in an iron vessel wherein zinc had been fused for several weeks continuously; this alloy was found deposited at the bottom of the vessel, and became an impediment to the melting operations, in consequence of its relative infusibility. In its physical aspect the alloy was of very much whiter colour, and crystalline structure entirely different from zinc; the alloy dissolved very readily and briskly in dilute sulphuric or hydrochloric acid, and was found, on analysis, to contain 4·6 per cent. of iron.

M. Zschiesche has prepared sulphate of lanthanium of such a purity that a thickness of 17 centimetres of a saturated solution gave no trace of the absorption bands of didymium. Working on this, he has found the atomic weight of lanthanium to be, from a mean of six experiments, 45·09. The extremes were 44·72 and 45·625.

M. E. Ludwig has come to the conclusion, as a consequence of a series of determinations of the specific gravity of chlorine gas, that this gas belongs to those vapours which only obey Mariotte's law when it is at a temperature rather remote from that at which it is condensed to the fluid state. The specific gravity of chlorine at 20° C. is 2·4807; at 50° C., 2·4783; at 100°, 2·4685; at 150°, 2·4609; at 200°, 2·4502. According to experiments made by Stas, the specific gravity of chlorine, deduced from its atomic weight, is 2·45012.

In order to obtain a platinizing fluid capable of platinizing copper, yellow metal, and brass, add, to a moderately-concentrated solution of chloride of platinum, finely-powdered carbonate of soda until effervescence ceases, next some glucose, and afterwards just so much common salt as will cause a whitish-coloured precipitate. When it is desired to apply this mixture for platinizing, the objects to be treated are placed in a vessel made of zinc and perforated with holes; the vessel is then placed, with its contents, for a few seconds in the mixture just described, which, just previous to using, should be heated to 60° C. On being removed from the zinc vessel, the objects are to be washed with water and dried in sawdust.

Professor Nicklès calls attention to the fact, that when chloride of sulphur of commerce is mixed with sulphide of carbon wherein phosphorus has been previously dissolved, a fluid is formed, which, though emitting fumes when in contact with air, is harmless, and may be for any length of time kept in well-stoppered bottles; on addition of liquid ammonia, however, or on passing into this liquid a few bubbles of ammonia gas, a most intense combustion at once ensues. This is due to the fact that the ammonia seizes upon the chloride of sulphur, forming chloride of ammonium, whereby so much heat is set free as to cause the combustion of the sulphide of carbon and phosphorus dissolved in it.

PROCEEDINGS OF THE CHEMICAL SOCIETY.

On Thursday, March 4, 1869, Mr. Tomlinson read his long-promised lecture "On Catharism, or the Influence of Chemically Clean Surfaces." He explained the sense in which he applied the new term, catharism (from *καθαρος*, *pure* or *clean*), distinguishing between "clean" in its ordinary and in its chemical sense. The finger could not be made chemically clean by any process, whereas a glass rod, cleansed with strong acids or alkalies, and well washed, was chemically clean, and no longer possessed the power of liberating either salt or vapour from liquids. The action of solid bodies in determining these changes he ascribes to the greasy film which, after exposure to the air, they are sure to acquire. For this film, the adhesion of the solid or vapour is greater than it is for the glass, and hence the effect of the solid. To such chemical uncleanness all phenomena of this kind should, he thinks, be ascribed, and he defines a nucleus as a body which "has a stronger adhesion for the gas, or the salt or the vapour of a solution, than for the liquid which holds it in solution." He repudiates the notion that temperature has anything to do with the phenomena of supersaturation, and describes experiments in which supersaturated solutions of various salts were kept for hours in catharized vessels at a temperature of 10° Fahr. without crystallization taking place. This was even observed with alum, which does not usually exhibit this peculiarity. The views of Löwel on crystallization and the phenomena of *soubresaut*, or bumping, during ebullition, were next discussed, and a variety of interesting facts were described. The action of porous bodies in assisting distillation was explained by their absorption of the vapour of the boiling liquids, which was subsequently given out in never-ceasing jets; and a number of obscure phenomena in chemistry—such as the passive condition of iron, and the slight action of sulphuric acid on pure and amalgamated zinc—were explained by the doctrine of catharism, for which the lecturer claimed the properties of a principle of nature—*viz.* generality and breadth of application—a principle which was as yet new to science.

At the meeting on March 18, 1869, a paper was read by Mr. Arthur Elliott, "On the Determination of Carbon in Cast Iron." The author's method consists in treating pulverized iron borings with solution of sulphate of copper, heating gently for ten minutes, when the iron dissolves, and metallic copper separates, the carbon remaining undissolved. Acid solution of chloride of copper is then added, and the mixture heated nearly to the boiling point, until the separated copper dissolves. The carbon is collected on a filter made of combustion tube, and stopped first with broken glass, and then loosely with ignited asbestos, and washed with boiling water till free from chlorides. It is then converted into carbonic acid, and the latter determined by oxidation with chromic acid.

A paper was then read by Professor G. G. Stokes, F.R.S., "On a Certain Reaction of Quinine." The reaction is best observed by diffused daylight entering a darkened room through a hole in the shutter of about 4 or 5 inches square, or a packing-case may be made to answer very well. The hole is covered with glass coloured a deep violet by manganese. In front of it is placed a white porcelain tablet; a solution of quinine in very weak alcohol, or very small fragments may be used. In some cases alcohol interferes with the reaction. The phenomena exhibited by sulphuric and hydrochloric acids were as follows:—When a drop of the quinine solution was touched by a rod dipped in dilute sulphuric acid, the fluorescence of the quinine was instantly developed. With hydrochloric acid no apparent effect was produced, but hydrochloric acid destroyed the effect of sulphuric acid; and if a little sulphuric acid were added to the drop containing only hydrochloric acid, no effect was manifest. The author found that, on trying a variety of acids, they ranged definitely into two classes, A and B—class A developing fluorescence like sulphuric acid, and class B destroying it, like hydrochloric acid. The classification made by the quinine reaction agrees almost exactly with the old distinction of ox-acids and hydracids. The author had found, however, that hyposulphurous acid, which is not usually ranked with the hydracids, ranged itself in class B, and led him to seek for other analogies between hyposulphurous and the hydracids; and he found that hyposulphite of soda restored the blue colour to litmus which had been reddened with chloride of mercury; he also found that, in common with the hydracids, it very readily decomposed cyanide of mercury. Mr. E. T. Chapman next read an abstract of a paper by himself and Mr. Miles H. Smith, "On the Butylic Compounds derived from Alcohol by Fermentation." The authors had operated on about 17 gallons of London fusel-oil. After subjecting it to a series of fractional distillations they obtained a body consisting of butylic alcohol, contaminated with small quantities of iso-butylic alcohol. From this butylic alcohol the authors prepared the iodide, bromide, nitrate, acetate, and nitrate of butyl, from which the iso-butyl compounds are separated by fractional distillation.

The anniversary meeting of the Chemical Society was held on Tuesday, March 30th, 1869, when the council and officers for the ensuing year were elected. The new President was A. W. Williamson, Ph.D., F.R.S.

At the next meeting, Thursday, April 1st, 1859, a paper, by Messrs. E. T. Chapman and Miles H. Smith, "On some Decompositions of the Acids of the Acetic Series," was read. Mr. W. H. Perkin, F.R.S., then made some remarks in reference to a paper published in the 'Chemical News,' by Fittig, "On the Constitution of Coumarin and Coumaric Acid." These papers only being of scientific interest need not be further alluded to here.

At the meeting on Thursday, April 15th, 1869, Mr. Chapman read a paper by himself and Mr. M. H. Smith, "On Propyl Compounds derived from the Propylic Alcohol of Fermentation." They operated on that portion of fusel-oil which remained after the amylic, butylic, and ethylic alcohols had been as perfectly as possible removed. Propyl alcohol is a colourless liquid of strong but not oppressive odour; it boils at 97° C., and its sp. gr. is 1·8120 at 16° C. On oxidation it yields propionic acid. Mr. Chapman then read a note "On Bromide of Amyl," by himself and Mr. M. H. Smith. They find that it is a mobile liquid, boiling at 121° C., and of sp. gr. 1·2173 at 16° C. They drew attention to the fact that the intervals between the boiling points of the bromides of methyl, ethyl, and propyl, are constant, *viz.* about 29° C.; that between bromide of propyl and bromide of butyl is only 22°, but that the interval between the bromides of butyl and amyl is again 29°. Professor Wanklyn then made a verbal communication touching the atomicity of sodium. He considered, from researches which had occupied him during some months, that sodium was an eminently polyvalent element.

At the meeting of the Chemical Society, on May 6th, 1869, it was agreed that the following petition should be presented to both Houses of Parliament:—

The Humble Petition of the President and Council of the Chemical Society.

Sheweth—That the Chemical Society was incorporated by Royal Charter for the general advancement of Chemical Science, as intimately connected with the prosperity of the manufactures of the United Kingdom. That in the opinion of your petitioners, the future intellectual position of Great Britain and her success as a manufacturing nation, are in a great measure dependent on the scientific education of her people. That the Society of Arts, in their report on technical education, assert that the only effectual systematic training for technical pursuits, consists of two steps—first, a thorough study of several branches of science, including chemistry; secondly, professional pupillage. That at the present time the study of natural science is altogether neglected in a large number of our secondary schools, while in the remainder it occupies only a subordinate position, both in respect of the time allotted to it and of the credit to be gained by proficiency in it. That the neglect of the study of natural science is in great part due to the influence exercised by the endowed schools, which by their number, their antiquity, and the large funds at their disposal, determine the course of studies in other schools, their own course of education representing the requirements of a past, rather than of the present age. That the necessity for inquiry into the teaching in endowed grammar-schools has already been recognized, by the appointment by Her Majesty of three commissions to report on this class of schools in England and Scotland. That the Schools Inquiry Commission have in their report pointed out various practicable means for the promotion and extension of the study of physical science in schools. Your petitioners, therefore, humbly pray your Honourable House to enact such laws as may procure for Chemistry, and other branches of natural science, as important a position among endowed school studies as that now occupied by Latin and Greek. And your petitioners will, &c.

Mr. J. Lothian Bell then delivered a lecture "On the Chemistry of the Blast-furnace." It is impossible to do more than refer to this exhaustive paper, in which every part of the operations going forward in the blast-furnace were passed in review, and the chemical actions going on explained. After the delivery of this lecture, a discussion followed, in which Mr. Siemens, Captain Noble, Mr. Crossley, Mr. Cochrane, and others took part. After Mr. Bell's lecture, Mr. W. Chandler Roberts gave a verbal account of, and exhibited the apparatus for showing the expansion of palladium by hydrogenium. It consisted of a coil formed with a strip of palladium and a strip of platinum, each being $300^{\mathrm{mm.}}$ long, $3^{\mathrm{mm.}}$ wide, and $0{\cdot}3^{\mathrm{mm.}}$ thick. This is put into a glass vessel filled with acidulated water; a plate or wire of platinum is placed near it, and the ribbon or wire connected with either pole of a battery by means of a commutator. The coil is first connected with the zinc pole of the battery, hydrogen is then thrown on the surface of the metal, which consumes the previously occluded hydrogen, and causes the index to move rapidly back to zero.

6. ENGINEERING—CIVIL AND MECHANICAL.

(*Proceedings of Societies and recent Publications.*)

In order to accommodate the increasing demand for facilities of transport fostered by the continued extension of our railways, lines of communication are now demanded in directions where, until recently, they were never thought of, and the passage of rivers—and other obstacles, which, in the early days of engineering, would have been carefully avoided—is now boldly effected as a matter of course. It is perhaps difficult to say exactly to what length of span a bridge may be built, but for practical purposes it is found that the largest spans are most easily obtainable with bridges constructed on the suspension principle. Coupling this fact with the recognized want of improved means of communication between this country and the Continent, M. Boutet has put forward a scheme for erecting a bridge across the channel from the Shakspeare Cliff, Dover, to Cape Blanc Nez, on the opposite coast; it is to consist of ten clear spans, each 3282 yards long (nearly two miles), with a platform 360 feet above the average sea-level. Impossible as we believe the realization of such a work to be, its author has, it is understood, succeeded in recommending his plan to the favourable notice of the Emperor of the French and Earl Granville. Projects have been put forward also for crossing the channel by means of a tunnel or subway, but the great question in connection with such works, and which must ultimately settle the point, is, Will they pay? Supposing it to be clearly demonstrable that they would prove remunerative when completed, is the yearly increasing traffic to be subject to the numerous inconveniences from which it now suffers during the many years such works would be under construction?

Very different, however, to the above schemes is the joint proposal of Messrs. John Fowler, James Abernethy, and William Wilson. According to this plan railway trains would be conveyed bodily across the channel on huge steam ferry-boats, built for the purpose, and provided with suitable harbour accommodation on either shore. The proposed route is from Dover to Andrecelles, at both of which places there exist facilities for constructing the necessary works. The laying down of a few miles of railway from Andrecelles to Wimereux would ease the journey from Calais to the latter station, and shorten the distance to Paris by fourteen miles. A bill for this "English and Continental Intercommunication" project was deposited last session, but it has, we understand, been postponed till next year for the adjustment of preliminary arrangements and for the further consideration of details.

PROCEEDINGS OF SOCIETIES.

Institution of Civil Engineers.—On the 2nd March last two papers were read on the subject of bridge foundations—one by Mr. Irvine Bell "On Sinking Wells for the Foundations of the Piers of the Bridge over the River Jumna, Delhi Railway," and the other by Mr. John Milroy, entitled "Description of Apparatus for Excavating the Interior of, and for Sinking, Iron Cylinders." In the former paper, the author, after describing the native plans of sinking wells by means of a spade called a "phaora," and, after the first five feet, by an implement called a "jham," proceeded to describe the mode of forming the foundations of the bridge over the Jumna at Sirsawa. In some instances the sites of the piers were got clear of water by diverting the river at different points during the dry season, while in other cases islands were formed by driving a half-circle of piles on the up stream side, then lowering sand-bags on the down stream side, to the height of four or five feet, and afterwards filling up with sand to five feet below low water. The curb was first sunk by men working with the "phaora" and basket, till the upper edge was within three inches of the level of the water, when a ring of brickwork was carried up to a height of six feet. The excavation of the interior was then proceeded with by means of the "jham" and divers in the old native style. Afterwards a further height of ten feet of brickwork was added, but the material was now removed by a sand-pump worked by a steam hoist of 4-horse power.

Mr. Milroy, in his paper, stated that the great desideratum, in cylinder sinking, had hitherto been some method of excavating the earth from the interior, without at the same time having to take out the water, and to keep it out during the operations. This object seemed to the author to have been attained by a machine of his invention, which was used in the construction of the bridge over the river Clyde, for the Glasgow Union Railway, a description of which he then proceeded to give.

A most interesting paper was read on 9th March "On American Locomotives and Railway Stock," by Mr. Zerah Colburn, the discussion on which extended over several evenings. In this a description was given of locomotive engineering in the States, and comparisons were drawn between it and the practice in this country. The paper was, however, too full of statistics and details to admit of a short abstract.

Mr. W. Shelford, in a paper "On the Outfall of the River Humber," described the estuary of that river as the outlet for the fresh waters from a drainage area of 10,500 square miles, or one-fifth of the whole area of England; but the present paper only treated of the outfall, the observations being arranged under four heads, *viz.*—1. The facts in connection with the past and present condition of the outfall, and of its peculiar features. 2. The ascertained alterations in the tidal *régime*. 3. The relative value of tidal and fresh water at the outfall. And 4. The relation of the operations of nature and of engineering works to the facts recorded.

"A Description of the Low-water Basin at Birkenhead," by Mr. J. Ellacott, read on 11th May last, stated that according to plans sanctioned by Parliament in 1844 and 1853 the Low-water Basin was intended chiefly as a deep-water access, and as a sort of refuge for shipping in the Mersey at all states of the tide. The basin is 1750 feet in length, 300 feet in width at the mouth, and 400 feet wide at the extreme end. The area is 14 acres, and the depth 12 feet 4 inches below low-water ordinary spring tides. A description of the piling was given by the author as well as an account of the sluicing arrangements. In 1866 an Act was obtained for converting the Low-water Basin into a wet dock.

Another paper was read at the same meeting by M. Jules Gaudard, of Lausanne, "On the Present State of Knowledge of the Strength and Resistance of Materials." The author stated that the theory of the strength and resistance of materials was closely connected with that of molecular mechanics; he then proceeded to consider the forces of various kinds to which materials were subjected, giving the results and formulæ of the most modern investigations.

Institution of Naval Architects.—The annual meeting of this Institution took place in March last, when several valuable and interesting papers were read. Of those which were of special interest to the engineer may be mentioned the following:—"On the Law of Resistance of Armour Plates," by Mr. William Fairbairn, LL.D., F.R.S.; "On the Stability of Floating Docks," by Mr. George B. Rennie; "Hydraulic Steering Gear," by Captain Inglefield, R.N.; "On Railway Communication across the Sea," by Mr. John Scott Russell, F.R.S.; "On Horse Power," by Mr. J. S.

Holland, R.N.; and on "Strains in Propeller Shafts," by Mr. W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

Association of Engineers, Glasgow.—At a meeting of this Association in April last, the President, Mr. John Page, C.E., read a paper on "Pipes and the Jointing of Gas and Water Mains." In alluding to the enormous waste of gas through leakage, Mr. Page reviewed the different modes of jointing at present in use, and dwelling on the difficulty in making and maintaining good joints under any circumstances, particularly in the curved pipes, he exhibited drawings of a very simple system, and clearly showed that a joint on a curved pipe made in that manner could not move; a joint tested under the most unfavourable circumstances having stood a pressure of 600 lbs. to the square inch.

A paper by Mr. Robert Burn, on "The Machinery used for Cleaning and Packing East India Cotton, and on the Application of the Seeds for Feeding Cattle," also deserves a notice, as dealing with a subject of first importance to India, and to the cotton manufacturers of this country.

Institution of Mechanical Engineers.—At a general meeting of the Institution of Mechanical Engineers, held at Birmingham on 29th April last, a paper was read by Mr. James S. E. Swindell, being a "Description of Guibal's Ventilating Fan employed at the Homer Hill Colliery, Cradley." This fan has eight vanes, and revolves on a horizontal shaft within a cylindrical casing of brickwork. The fan is 16½ feet in diameter, and 4¾ feet wide; its usual working speed is twenty-six revolutions per minute, discharging 13,500 cubic feet of air per minute; but it can be got up in one minute's time to ninety-six revolutions, discharging 51,700 cubit feet per minute. This is the first mechanical ventilation that has been applied in the working of the South Staffordshire thick or ten-yard coal. It has now been running about nine months without a single stoppage for repairs. The total cost of the fan, with engine and connections, is only about one-third of that of an ordinary ventilating furnace for producing the same amount of ventilation.

Another paper, by M. E. Gellerat, of Paris, was a "Description of the Steam Road Roller used in Paris." This roller consists of a locomotive engine carried entirely upon two large cast-iron rollers of equal size, which are both driven by the engine, the course of the machine being controlled by a special arrangement for changing the direction of the roller axles. The results of numerous data show that the cost of horse rolling in Paris is about 14*d.* per ton per mile, whereas for steam road rolling the actual payment is only half that amount, or 7*d.* per ton per mile, including the contractor's profit.

LITERATURE.

'A Treaties on Lathes and Turning, Simple, Mechanical, and Ornamental,'* by W. Henry Northcote. This work is calculated to prove a useful addition to the mechanical engineer's library, and will be referred to with interest by both professional men and amateurs. It is divided into four parts. The first part contains a general description of the different kinds of lathes in general use, with a statement of the points which constitute a good lathe, and a glossary of the technical terms in general use by turners. The second part treats of the use of the hand lathe, and it comprises five divisions, relating to plain turning with hand tools, hand turning in metals, screw chasing, drilling and boring, and miscellaneous operations. The third part enters into a description of a "multi-purpose" lathe designed by Mr. Northcote himself; and this is followed by remarks on self-acting traverse and surface turning, self-acting screw cutting, self-acting drilling and boring, turning irregular shapes, wheel cutting, milling or circular cutter making, fluting or grooving, facing and slot-drilling, planing and slotting, and on attention to lathe, repairing tools, &c. And the fourth part enters into particulars on the subject of ornamental turning.

'The Elasticity, Extensibility, and Tensile Strength of Iron and Steel,'† by Knut Styffe, Director of the Royal Technological Institute at Stockholm. Translated from the Swedish, with an original Appendix, by Chester P. Sandberg, A.I.C.E. With a Preface by John Percy, M.D., F.R.S.. This volume is the result of certain experiments recently made by its author. It contains a full account of those experiments and of the apparatus by the aid of which they were carried out. The subject is divided into four chapters: the first, treating of experiments on tension at ordinary temperatures; the second, on the application of the results of these investigations to the determination of the relative values of steel and iron, and of the different varieties of these materials for various purposes; the third, of experiments on tension at high and low temperatures; and the fourth, of experiments on flexion at different degrees of temperature. To these chapters are also added certain tables and plates, and an Appendix by Mr. Sandberg. The record of these experiments forms a valuable addition to the information obtained by Mr. Kirkaldy on the same subject; much, however, yet remains to be done in the matter of iron and steel testing, and it is to be hoped that further experiments will be undertaken, with the view of arriving at conclusions upon those points which do not as yet appear to have been satisfactorily settled.

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* Longmans, Green, & Co., London.

† John Murray, London.

7. GEOLOGY AND PALÆONTOLOGY.

(*Including the Proceedings of the Geological Society, and Notices of Recent Geological Works.*)

Few regions of the earth present to the physical geologist a more wondrous display of volcanic phenomena on a grand scale than the Hawaiian group of islands in the Pacific Ocean. These remote intertropical isles (twelve in number) are all of volcanic origin with the exception of the ancient elevated coral reef and resulting limestone.

Since their first discovery by the Spaniards they have been repeatedly visited by government exploring expeditions, but by far the largest share of their physical history has been collected by one man, the Rev. Titus Coan, for more than thirty years a most devoted missionary at Hilo on Hawaii, the largest of the group. This gentleman sends to 'Silliman's American Journal,'* some interesting notes on the recent volcanic disturbances of Hawaii. Although not on so grand a scale as many of the eruptions which have occurred in former years, yet Mr. Coan's account furnishes information on many points of great interest to the geologist. One feature frequently observed in the volcanic outbursts on these islands is the opening of lateral subterranean rents, into which the overflowing craters discharge their pent-up lava-streams. In the case of the outburst of April, 1868, when the craters of Kilauea and Mauna Loa both seem to have been in a state of eruption, their united lava-streams appear to have discharged into a line of fissure, having a south-westerly trend, along which they flowed subterraneously for a distance of more than thirty miles, appearing on the surface near Kahuku, running thence for ten miles like a vast serpent through the beautiful pasture-lands, and giving off various minor branches, they finally reach the sea in two great streams only 1000 feet apart, enclosing between them an island five miles in length. On this narrow belt of land three houses are left standing near the shore, and some thirty head of cattle were rescued alive (though terribly scorched) after the flow had ceased; so rapid was the rush of the lava-rivers that cattle grazing on the plains were surrounded before they were aware of their danger. A family of four persons in a house were enclosed on an island formed by the igneous flood, and remained prisoners for ten days, when they were able to leave their retreat unharmed.

Along the whole line from Kahuku to Kilauea, the subterranean flow was marked by fissures and displacements of the ground, through which jets of steam and lava issued in several places, whilst along the hill-flanks the earth was rent, and the surface deposits of earth, boulders, rocks, lavas long-buried, trees, &c., were hurled in one vast avalanche over the plain beneath, a distance of several miles, filling the air at the same time with dry dust. On the night of the earthquake the fires in the great crater went out, and the central area of the great plateau sagged gently down about 300 feet, carrying with it its botanical garden of tree-ferns and "ohele" bushes (*Vaccinium*) still standing.

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* Vol. XLVII., No. 139, p. 89.

A very full account of the entire group with excellent maps and illustrations, and a description of all the modern eruptions, will be found in the recently published 'Memoirs of the Boston Society of Natural History,' by William T. Brigham, A.M.*

Mr. Peacock's book† 'On Evidences of Vast Sinkings of Land on the North and West Coasts of France and the South-Western Coasts of England,' is made up of an *olla podrida* of antiquarian scraps and extracts from the writings of all sorts and conditions of men, from Ptolemy the geographer, A.D. 117, down to Mr. Raphael Pumpelly in 1868.

The author at the end of his labour concludes there is good reason for believing that there has been considerable subsidence on the coast and about the Channel Islands within the historical period, which from an examination of the wear and tear of the coasts on both sides of the Channel, and of the submerged forests on the shores at low water, any geologist would be ready to admit, on geological grounds, without the very doubtful assistance of Ptolemy or Diodorus Siculus.

The tract 'On Steam as the Motive-power in Earthquakes and Volcanoes,'‡ bound up with the above and written by the same author, contains a full compilation of geological authorities in support of the doctrine that steam is the chief agent in volcanic action, but without any original idea, unless the suggestion that the vast necleus of the globe, about 6000 miles in diameter, consists of *pumice*. A serious objection to the book is the badness of the typography and the great number of printer's errors, which render it often unintelligible to the general reader.

Of Mr. Samuel Mossman's 'Origin of the Seasons,§ considered from a Geological Point of View,' the most kind reflection we can make is, "What a pity it was ever written!" Imagine a man suggesting that the curative qualities of the climate of Australia ‖ in cases of consumption is due "to the presence of a larger volume of carbonic acid gas in the atmosphere than exists here!!!"

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* Vol. I., part iii., 1868.

† 'Physical and Historical Evidences of vast Sinkings of Land on the North and West Coasts of France, and South-western Coasts of England, within the Historical Period.' Collected and commented on by R. A. Peacock, Esq., C.E. 8vo, pp. 190. London: E. and F. N. Spon; and the author, St. Helier, 1868.

‡ Pp. 56.

§ William Blackwood & Sons, Edinburgh, 1869. 8vo, pp. 472.

‖ P. 424.

Mr. Mossman's book is a most wonderful compilation of extracts, strung together by such original pieces of fine writing as the following:*—"Let us imagine the sea boiling, bubbling, and steaming above the domes of red-hot trachyte, swelling and bursting as they rose towards its surface, and then ejecting through volcanic cones and yawning fissures such masses of lava as to form so many thousand miles of mountains; let us conceive the shocks and quakes of the earth in this era of her travail, when the pent-up volcanic forces caused her to rend the solid framework of her sphere a perturbed daughter of the sun, the most convulsive child of the solar system."!!

'Geological Fragments collected principally from Rambles among the Rocks of Furness and Cartmel'† (Lancashire), by John Bolton, is a description by a humble geological worker (an entirely self-taught man) of the various excursions in and about Furness and Cartmel, with notes on the formations and fossils to be seen, and the scenes and people among which he has worked; but we hardly think it will be read by many beyond the author's circle of friends.

'Chips and Chapters, a Book for Amateurs and Young Geologists,' is the title of a small 8vo volume of 300 pages, by that indefatigable writer, David Page, LL.D., F.G.S., &c.‡ This is intended as a reading-book for the many, and is an endeavour on the part of the author to put before the general public some of the more prominent facts and bearings of geological science in a readable form. The utility of "Geology as a Branch of Education"§ is a chapter deserving of especial study. We hope the author may be as well satisfied with the sale of his book as we are with its perusal.

On Physical Geology there are contributions by G. Poulett Scrope, "On the Supposed Internal Fluidity of the Earth,"‖ and "On the Influx of Water as the Cause of Volcanic Eruptions;"¶ by Dr. T. Sterry Hunt, "On the Probable Seat of Volcanic Action;"** by Mr. David Forbes, "On the Nature of the Interior of the Earth.'††

In the first paper Mr. Scrope argues in favour of the interior mass of the earth being held down in a solidified form by the weight, cohesion, and perhaps increasing contraction of the solid crust above, yet retaining in this state its intense expansibility, and being ready, at all points, to return to the fluid or gaseous state, and make its escape whenever—by a fissure or disturbance of the superincumbent crust—that pressure is partially removed. In the second paper Mr. Scrope refers to steam as the recognized agent in forcing up lavas through narrow and crooked fissures in the solid crust of the globe, and concludes, from the cellular and porous condition of most lavas, that water was present, in a finely divided state, disseminated through the entire mass. Dr. T. Sterry Hunt calls attention to the views of Keferstein and others, that all crystalline non-stratified rocks, from granite to lava, are but the products of the transformation of sedimentary strata.

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* 'On Volcanic Forces in South America, &c.,' p. 101.

† Ulverston: D. Atkinson; and London: Whittaker & Co. 8vo. 1869. Pp. 264.

‡ Edinburgh and London: Blackwood & Sons.

§ Pp. 78–104.

‖ 'Geological Magazine' (April), p. 145.

¶ Ibid. (May), p. 196.

** Ibid. (June), p. 245.

†† 'Popular Science Review' (April), p. 121.

Mr. David Forbes concludes, after reviewing the evidences (as to the nature of the interior of the earth) *pro et contra*, that the balance of argument appears to be in favour of the older theory, that the earth is a central molten mass, surrounded or enclosed by a comparatively thin solid crust or shell; and further, seems to indicate the probability that its interior, besides consisting mainly of molten silicates, also contains a great accumulation of the heavy metals and their compounds.

Mr. N. Plant having brought home some plant-remains from Coal-beds of true Carboniferous Age in Brazil,* they have been examined and referred by Mr. Carruthers to the genera *Flemingites*, *Noeggerathia*, and *Odontopteris*.†

Professor Owen has described a remarkably perfect jaw of a Cestraciont fish, from the Oolite of Caen in Normandy, under the name of *Strophodus medius*.‡ Its likeness to the recent Port Jackson Shark is very great.

Mr. Henry Woodward adds a new genus of Ophiuroid Starfishes to the Upper Silurian of Dudley.§

Mr. Thomas Davidson contributes a series of notes on Continental Geology, relating chiefly to the classification of the Cretaceous system in France, England, Germany, &c.‖

'The Transactions of the Edinburgh Geological Society,'¶ consist of papers read before that Society to May, 1868. "The Carboniferous Strata of Carluke," "The Old Red Sandstone of Scotland," "The Superficial Deposits of the South Esk," "Glacier Action in Galloway, the Coasts of Antrim and Londonderry," "The Miocene Beds of Greenland," "The Precious Stones of Scotland," are among the subjects treated of in this volume. There is every prospect of this Society, which is now under the presidency of Mr. Archibald Geikie (Director of the Geological Survey of Scotland), continuing to do good work.

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* 'Geological Magazine' (April, 1869), p. 147.

† Ibid., p. 151.

‡ Ibid. (May), p. 193.

§ Ibid. (June), p. 241.

‖ Ibid., pp. 162, 199, and 251.

¶ 1868. Vol. I., parts i. and ii.

'The Transactions of the Geological Society of Glasgow'* is marked by Sir William Thomson's celebrated paper "On Geological Time." Considering the motions of the earth, with a careful regard to the effect of resistance and retardation by tidal influence, &c., and viewing the sun as we should any large mass of molten iron, or silicon, or sodium, he comes to the conclusion that: (1) The earth formerly rotated more rapidly than at present, and that its speed is slowly, but certainly diminishing by resistance. (2) That the sun's energies in giving light and heat are being dissipated year by year, and that there is no sufficient supply of new matter falling into the sun's orbit to replenish that energy. (3) That the sun may have illuminated the earth for 100 millions of years, but that it is almost certain that he has not illuminated it for five times that period. (4) From the author's investigations of underground temperatures and the secular cooling of the earth, he infers that the present condition implies either a heating of the surface within the last 20,000 years of as much as 100° Fahr, or a greater heating all over the surface at a more remote period. (5) Sir William Thomson shows, in conclusion, that taking the largest grant of time, and commencing with the earth at a temperature sufficiently high to melt its entire mass, we must admit a limit of between 50 millions and 300 millions of years, beyond which our drafts on the bank of Time cannot be honoured. (6) The Dynamical theory of the sun's heat renders it impossible that the earth's surface has been illuminated by the sun many times 10 million years. (7) Finally, he concludes that the existing state of things—including life on the earth—must be limited within some such period of past time as 100 million years. We should like to notice Messrs. James Geikie, "On Denudation in Scotland since Glacial Times;" Archibald Geikie, "On Modern Denudation," and "On the Silurian Rocks of Scotland;" Mr. Edward Hull, "On the Causes which seem to have regulated the relative Distribution of the Calcareous and Strata of Great Britain, with special reference to the Carboniferous Formation;" besides many other excellent papers, but our space does not permit.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY OF LONDON.

The May number of the 'Quarterly Journal'† furnishes us with the Annual Report, the Anniversary Address by the President, and the papers read before the Society from December 23, 1868, to February 24, 1869. The income expected this year (1869) amounts to 2072*l.* 16*s.*, and expenditure to 1893*l.*, leaving a balance in favour of the Society of 179*l.* 16*s.*; whilst the funded property amounts to 4860*l.* 14*s.* 6*d.*, exclusive of trust-fund. We may, from the above statement, safely congratulate this learned body upon its healthy financial condition. The President (Prof. Huxley) takes, as the text for his Anniversary Address, the subject matter of Sir William Thomson's article "On Geological Time," already briefly epitomized in this present Chronicle.

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* 1868. Vol. III., part i.

† Edited by Mr. W. S. Dallas, the new assistant-secretary.

Commencing with a brief review of the various lines of thought which a study of geology has developed, the author divides them into three classes—Catastrophists, Uniformitarians, and Evolutionists; with the two former classes of thinkers we were well acquainted, but the third is a new class, defined as those who "embrace in one stupendous analogy the growth of a solar system from molecular chaos, the shaping of the earth * * * to its present form, and the development of a living being from the shapeless mass of protoplasm we term a germ."

Assuming that Sir W. Thomson is correct in asserting that life on the earth must be limited to 100 million years, Professor Huxley shows that the whole thickness of stratified rocks, taken at 100,000 feet, or about $56\frac{3}{4}$ miles, could have been formed within that period of time if only $\frac{1}{1000}$ of a foot or $\frac{1}{83}$ of an inch of sediment were deposited annually.

He points out that although so much stress is laid by Sir W. Thomson on retardation, yet "it is not absolutely certain, after all, whether the moon's mean motion is undergoing acceleration, or the earth's rotation retardation; and yet this is the key to the whole position." "If the rapidity of the earth's rotation is diminishing, it is not certain how much of that retardation is due to tidal friction, how much to meteors, how much to possible excess of melting over accumulation of polar ice during the period covered by observation, which amounts, at the outside, to not more than 2600 years."

One of the most acute and telling remarks in the address is that contained in the following paragraph:—

"I do not presume to throw the slightest doubt upon the accuracy of any of the calculations made by such distinguished mathematicians as those who have made the suggestions I have cited. On the contrary, it is necessary to my argument to assume that they are all correct. But I desire to point out that this seems to be one of the many cases in which the admitted accuracy of mathematical processes is allowed to throw a wholly inadmissible appearance of authority over the results obtained by them. Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends on what you put in; and as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data."

The most important papers contained in the 'Journal of Proceedings' are Mr. T. W. Kingsmill's communication on the Geology of China, especially with reference to the Province of the Lower Yangtse; Prof. Huxley's paper "On the genus *Hyperodapedon*," a reptile found in the Triassic deposits of Elgin (once said to be of Devonian age). From remains found of late in Warwickshire and Devonshire the author has determined its Lacertilian character, and considers its nearest fossil ally to be the Triassic genus *Rhynchosaurus*, and at the present day the singular genus *Sphenodon*, or *Hatteria*, found in New Zealand.

Mr. Edward Hull has an ingenious and suggestive paper "On the Evidence of a Ridge of Lower Carboniferous Rocks crossing the Plain of Cheshire beneath the Trias, and forming the Boundary between the Permian Rocks of the Lancashire Type on the North, and those of the Salopian Type on the South."

The Rev. T. Wiltshire, "On the Hunstanton Red Chalk," adds to our knowledge of this interesting local deposit, which from all the evidence, both lithological and palæontological, appears to be the representative at Hunstanton of the upper portion of the Gault of Folkestone.

The other papers are: Messrs. King and Rowney "On the so-called 'Eozoonal' Rock;" Mr. Whitaker "On the New Locality for *Hyperodapedon* on the coast of Devon;" Mr. W. H. Baily "On the Irish Graptolites" and "On Tertiary Plant-remains from Antrim;" Mr. G. T. Clark "On the Basalt Dykes of India;" Dr. Sutherland "On the Auriferous Rocks of South-eastern Africa;" Mr. W. Boyd Dawkins "On the Distribution of the British Post-Glacial Mammals;" and a postponed paper by Mr. J. Wood Mason "On *Dakosaurus*, from the Kimmeridge Clay of Shotover Hill."

8. METEOROLOGY.

In a recent part of the Proceedings of the Meteorological Society there is a very suggestive paper by Mr. Meldrum, containing some interesting results as to the origin of cyclones in general, to which he has been led by his study of the weather of the Indian Ocean. In our last number we noticed the Synoptic weather charts which Mr. Meldrum is preparing for publication. The examination of these charts affords abundant confirmation of an idea which he has long entertained, and which is traceable in many of his papers, *viz.*

that most of, if not all, the atmospherical disturbances experienced in those seas may be referred to the mutual interference of the two great currents of air, whether these be the ordinary polar and equatorial currents, the S.E. and N.W. winds of the South Temperate Zone, or the S.E. trade and the N.W. monsoon met with nearer the equator. When these opposite currents are flowing in parallel channels at the earth's surface, the resulting action on the atmosphere in general differs according to their position as regards latitude. When the bed of the polar current is in a latitude higher than that of the equatorial, *i.e.* when the S.E. wind lies to the southward of the N.W. wind, atmospherical pressure has a tendency to decrease between them, and ultimately the wind begins to circulate round the area of depression, in the direction of the hands of a watch. A cyclone is ultimately formed, and in it the force of the wind is stronger at the centre than at the circumference. When the position of the currents is reversed, a barometrical maximum is produced, around which the wind revolves in the direction opposite to that of the hands of a watch. In short an "anticyclone" is formed, in which the wind-force is usually very light in the centre but stronger outside. It is hardly necessary to observe that as we are dealing with the Southern Hemisphere, the conditions of the direction of the wind's motion are exactly the reverse of what obtains in this hemisphere. Mr. Meldrum asserts that cyclones *invariably* have their origin as we have described. They commence at the southern edge of the N.W. monsoon, and travel obliquely across the S.E. trade.

If this theory be found to be completely trustworthy, we may hope that it will be possible to assign an origin to the West Indian hurricanes, which will be more satisfactory than that given hypothetically by Dove, who attributes them to the fact that by some means or other a portion of the upper current (antitrade) between the tropics has been forced out of its proper stratum into the true trade wind below it, so that an eddy, ultimately resulting in a hurricane, has been formed. This is, after all, something like the convulsion theories of the older geologists. If we can find that ordinary causes are capable of producing certain effects, it is well to satisfy ourselves, whenever these effects are observed, that these causes were not in operation, before we call in a *deus ex machinâ* of any sort to produce the required action.

We see from the report of a lecture delivered at the Royal Institution on April 30 by Mr. Scott, that the Meteorological Office has been led, independently of Mr. Meldrum, to results similar to his, and we may hope that useful results will come out of the inquiry.

The Journal of the Scottish Meteorological Society for January contains a good paper by Mr. Buchan "On the Mean Monthly and

Annual Pressure in Scotland." He has investigated the returns from fifteen stations for eleven years, and the results obtained afford, as might be expected, a strong corroboration of the principle that the motion of the air is related to the differences of atmospherical pressure. The mean annual pressure decreases from east to west and from south to north, and as the wind always blows with the lowest barometrical reading on its left hand side, we see that the general conditions of pressure are in harmony with the fact that our prevalent winds are south-westerly.

The monthly curves exhibit three minima and three maxima; the former occurring in January, March, and October; the latter in February, May, and November.

The depression in January increases as we go northwards, while that in March changes in the opposite direction. In October the decrease is nearly uniform over the whole of Western Europe.

As regards the maxima, that in February is of slight extent. In May the absolute maximum for the year is reached, corresponding to the period of prevalence of our east winds. The increase of pressure in November is the phenomenon so long noted as the great November wave, to which it is not now the fashion to attribute nearly so great an influence on our weather as it was some few years ago. This paper is a very useful contribution to meteorology, as the results of eleven years' observations may be fairly considered as worthy of attention.

The 'Atlas Météorologique' for 1867, published by the Observatoire Impérial, contains an elaborate paper by M. Becquerel, on the influence of forests on climate. The paper is very carefully written, but on reading it proves somewhat disappointing, as it leads to very few practical results, owing to a deficiency of evidence on many questions.

There is one action which all vegetation, of whatever character it be, exerts, and that is the protection of the soil on which it grows from forcible removal by floods. The roots traverse the earth in all directions, and bind it together, while the branches break the force of the rain as it falls. As soon as a hill-side is cleared of forests, the rivulet-beds are scored deeper and deeper, and the soil is gradually washed down, leaving the rocks bare. The roots of trees have, in addition, a tendency to facilitate the percolation of water to the subsoil, and thus to prevent its accumulation on the surface, and the consequent production of swamps, such as have been formed in parts of France within historic times. There is another beneficial effect produced by trees, that of impeding the motion of the air, and thus affording shelter from wind. This action is, of course, limited, depending on the height of the trees and the direction of motion of the wind. If this direction be horizontal the shelter afforded is very considerable, as it has been noticed in Provence that a hedge two mètres in height shelters a space 22 m. in width from the effects of the "mistral." Lastly, trees have a decided influence on health, in protecting a district from unwholesome exhalations. It is found along the edge of the Pontine marshes that the existence of a belt of wood is sufficient to ensure immunity from malaria to the peasants who live behind it. These then are the most obvious beneficial effects on climate of the presence of forests in a country. As regards the direct influence of vegetation on the temperature and the climate generally, the author gives the notes of some experiments which he has made on growing trees, in order to determine their temperature and that of the surrounding air at different times of the day. The results seem to show that trees behave as if they were dead or inorganic bodies, receiving heat from external sources and radiating it to surrounding objects. The heat developed in the process of growth was found to be quite inappreciable by means of the instruments employed, while the cooling influence usually assigned to foliage, owing to the constant evaporation going on from its surface, was shown to be utterly unfounded. However, this part of the paper is quite incomplete, as M. Becquerel reserves the exact account of his inquiry for a future essay. He distinctly denies the truth of the change of climate alleged to have taken place in various countries, and attributed to the clearing of the land, without, as it seems to us, investigating the question thoroughly.

The ultimate conclusions stated in the paper are, as we have said before, unsatisfactory; *e. g.* we are told that the effect of cutting away the forests is to diminish the quantity of running water in the country, but the comparison of observations of rainfall in a district, before and after the clearing, have most decidedly *not* led to the conclusion that the amount of rain which falls is seriously affected by the clearing. We do not therefore learn to what action the reduction of the amount of river water is to be attributed.

On the whole the paper may be fairly compared to Darwin's first work 'On the Origin of Species.' Both works contain many facts of great interest which have a certain relation one to another, while the reasoning which should bind the whole together is for the most part entirely wanting. We hope that M. Becquerel's promised paper will be more conclusive than this one.

Before we leave the subject of meteorology in France, we should say that it appears from the Bulletin Hebdomadaire of the Association Scientifique, that the plan for the establishment of a central Physical Observatory in Paris and the proposed modifications in the management of the Observatoire Impérial, the result of which would have been to put a stop to all but the astronomical work carried on there, have both been brought to an end. M. Le

Verrier announces that the Observatoire will continue to perform all its functions as heretofore.

The Norddeutsche Seewarte, in Hamburg, has published its first Annual Report, and Herr Von Freeden, the Director, promises two other publications within a brief space. These will be an account of the German North Polar Expedition of last year, under Captain Koldewey,* and a weather calender for north-west Germany, the latter being the discussion of his own observations made at Bremen during the past ten years. The Report is to a great extent taken up with the account of the preliminary negotiations which led to the establishment of the Seewarte by the shipowners of Hamburg and Bremen. Marine meteorology has been the chief object of the institution, and the director has set to work very vigorously in this line. In order to induce the shipping interest of the towns to co-operate warmly in the work of the office by making observations at sea, the direction has proceeded to frame minute sailing directions for the several voyages, and the Report contains a practical proof of the value of scientific meteorology to trade, in the form of a tabular statement of the total amount of gain in time exhibited by the runs made by vessels furnished with these directions, as compared with passages made by other ships between the same ports at the same time. The sailing directions are very definite in their character, for one of the objects of their issue has been to supply information more thoroughly digested, and in fact more practical than Maury's works can afford.

The Report is professedly only the account of the activity of one department of the office, but hopes are held out that at some future time its operations may be extended to land meteorology also. The only work of this nature which is carried on is the publication of daily observations made at Hamburg, and of occasional storm telegrams received from our own Meteorological Office. It is interesting to see that these messages have been of practical use, notwithstanding the great distance of Hamburg from London, for out of thirty-seven messages sent, more than half were followed by storms, while in only three instances did the storm precede the warning.

The long promised charts of surface temperature for the South Atlantic Ocean have now been published by the Meteorological Committee. They contain the mean monthly surface temperatures for five-degree squares, calculated from the data collected by Admiral Fitz Roy out of Board of Trade registers, and in addition the mean temperatures for strips of 5° of longitude, but for each degree of latitude published in 1861 by the Meteorological Institute of Holland. The charts are illustrated by copious notes, consisting of extracts from the logs of captains, who have noticed sudden changes of temperature and thus tending to show where the actual boundaries of the various ocean currents lie.

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* This work has already been published, but a notice of it must be reserved for the next Chronicle.

Meteorologists will hail these charts as a useful contribution to Marine Meteorology, and as a first instalment of the publication of the partly finished work found by the committee in the office when they took charge of it.

We are glad to learn that H.M.S. 'Porcupine' has been placed at the disposal of Dr. Carpenter and his friends, in order to carry out a more extensive series of deep-sea soundings and dredgings than was possible during their short cruise last autumn. We hope that by this expedition some light may at last be thrown on the vexed question of deep-sea temperatures.

Mr. S. Barber sends us the following account of the Aurora Borealis, observed by him near Liverpool. The two remarkable appearances of Aurora Borealis which occurred lately, afford some peculiar and noteworthy points of comparison, in addition to the fact of their unusual brilliancy and striking form, and their proximity to each other; the last in point of time, on May 13th, showed greater steadiness and a whiter light, the flashes being feeble and indistinct. The rays of electric light, arched, broad, and white, over the entire heavens, converging to an irregular nucleus, situated about 10 degrees S.S.E. of the zenith. This nucleus had a jagged edge and an irregular cavity within it, and its form changed rapidly, one half of its body disappearing in less than a minute. The space between the streamers was very small, and a very light greenish blue colour produced a remarkable effect. The previous Aurora presented much stronger contrasts of colour, and greater radial definition. The light was more limited in extent, and the rays most distinct from north to west, from which quarter, and from N.W., were rapid and brilliant flashing streamers, having a wave-like and tremulous motion, as of bands of ribbon violently shaken; these converged, as in the former case, to a point not far from the zenith, and nearly coincident with that of the nucleus in May. It is worthy of notice that a long period of cold wet weather followed these remarkable phenomena, the wind ranging from east to north. The above notes were taken from about 10 to 11½ P.M.

9. MINERALOGY.

EXACTLY eighty years ago, the German chemist, Klaproth, discovered a new earth, or metallic oxide, in a certain mineral found in the sands and gravels of Ceylon, and occasionally cut and polished as a gem. As this mineral had long been known under the name of *zircon*—a word apparently of Arabic origin—the new earth received the appropriate name of *zirconia*. The same oxide was likewise found in the brightly-coloured stone known as the *hyacinth*—not indeed the hyacinth of the ancients, which appears to have been our sapphire, but the gem so-named by the modern mineralogist—and it was then demonstrated that the zircon and hyacinth are virtually the same mineral, both being silicates of zirconia. In 1845, the Swedish chemist, Svanberg, endeavoured to show that in the zircons of Norway and of the Urals the zirconia is accompanied by another substance which he termed *noria*; but whether this is really a distinct earth has not been satisfactorily determined. About three years ago, Professor Church was led to examine several specimens of zircon under the micro-spectroscope; and observing that some of them exhibited peculiar absorption bands, not given by pure silicate of zirconia, he conjectured that they might possibly be due to the presence of Svanberg's norium. Utterly ignorant of Professor Church's observations—the results of which were published only in the shape of a letter inserted in a popular journal—Mr. H. C. Sorby has for some time past been engaged in the spectroscopic examination of the zircons of Ceylon. When light is transmitted through certain transparent specimens of zircon, and is then analyzed by the eye-piece of his spectrum-microscope, it is seen that the luminous spectrum is traversed by more than a dozen well-defined narrow black lines. As these absorption bands are not given by any other known substance, Mr. Sorby regards them as indicating the presence of a new earth associated with zirconia; and as they are exhibited chiefly by those pale-coloured varieties of zircon which are known as *jargoon* or *jargon*, he proposes to name the new metal *jargonium*. Professor Church, however, has suggested for this supposed element the name of *nigrium*. It would appear from Mr. Sorby's further researches that the earth jargonia is capable of existing in two distinct allotropic conditions, having different densities and different optical properties. Comparatively few Cingalese jargons exhibit in their natural state well-marked lines, but by exposing an ordinary specimen for some time to a bright-red heat the altered mineral gives a spectrum which is traversed by a fine series of absorption bands.*

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* 'Chemical News,' March 12, April 16 and 30, 1869; also paper printed for private circulation at soirée of the Royal Society.

In association with Mr. P. J. Butler—a gentleman possessing a fine collection of gems—Mr. Sorby has presented to the Royal Society a paper "On the the Structure of Rubies, Sapphires, Diamonds, and certain other Minerals."* They find that the sapphire exhibits numerous cavities, sometimes reaching $\frac{1}{10}$th of an inch in diameter, and either partially or entirely filled with a liquid—probably condensed carbonic acid. Small triangular lamellar crystals are also to be noted as common inclosures in this gem. The ruby differs from the sapphire—although of course chemically the same stone—in that it contains fewer fluid-cavities and more included crystals, some of which are octohedral in form, and are probably minute spinel rubies. In certain spinels from Ceylon, the fluid-cavities contain a colourless liquid, accompanied by either a solid substance or a very viscous fluid in which small crystals are embedded. Many emeralds are extremely full of fluid-cavities, containing what appears to be a strong saline solution with cubic crystals—probably of chloride of potassium. By examining several diamonds, the authors find that the embedded black specks, which Brewster imagined might be cavities, are really inclosed crystals. Some of these are surrounded by cracks indicating contraction in the neighbouring mass; and this indication is strengthened by the appearance of a black cross surrounding the crystals when examined by polarized light. The authors' general conclusions drawn from these observations "seem to show that the ruby, sapphire, spinel, and emerald were formed at a moderately high temperature, under so great a pressure that water might be present in a liquid state. The whole structure of the diamond is so peculiar that it can scarcely be looked upon as positive evidence of a high temperature, though not at all opposed to that supposition."

When Mr. David Forbes, more than eighteen months ago, published the first part of his researches in British mineralogy, he described at length the results of his examination of our Welsh gold. Since then, his attention has been directed to the gold-bearing districts of England, Ireland, and Scotland, as represented respectively by the counties of Cornwall, Wicklow, and Sutherland.† By examining specimens from each of these localities, Mr. Forbes is enabled to place in our hands a series of analyses of gold from every quarter of the British Isles—a series peculiarly valuable, inasmuch as our knowledge of the chemical composition of British gold has hitherto been remarkably defective. As we have already published his analyses of Welsh gold,[*] we need only here quote the English, Irish, and Scotch analyses:—

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* 'Proceedings of the Royal Society,' xvii., No. 109, p. 291.

† 'Philosophical Magazine,' May, 1869, p. 321.

	Cornwall.	Co. Wicklow.	Sutherlandshire.	
Specific gravity	16·52	15·07	15·799	
			I.	II.
Gold	90·12	91·01	81·11	81·27
Silver	9·05	8·85	18·45	18·47
Silica[†]	0·83	0·14	0·44	0·26
	100·00	100·00	100·00	100·00

On examining these analyses, one cannot fail to remark the large amount of silver alloyed with the Sutherlandshire gold as compared with the proportion present in gold from other parts of the British Isles. Any remarks on the occurrence and distribution of our native gold are rendered unnecessary by Mr. Robert Hunt's excellent paper on the subject published in a former volume of this Journal.[‡]

A Devonshire mineral, used at one time as an iron-ore, has been found by Mr. Forbes to have the composition of *Babingtonite*—a rare species, found chiefly at Arendal, in Norway. Our British Babingtonite presents a radiated fibrous structure, a blackish-green colour, and a composition represented by the formula:—

$$6\,CaO\,.\,SiO_2 + 3\,FeO\,.\,SiO_2 + Fe_2O_3\,.\,3\,SiO_2.$$

On more than one occasion it has been our duty to call attention to Vom Rath's discovery of a new form of silica called *Tridymite*. Professor Maskelyne has lately found this interesting species, or a very closely-allied mineral, in the meteorite of Breitenbach, in Bohemia.[§] The crystals, although imperfect, are apparently hexagonal in form, whilst their composition shows them to consist of almost pure silica. From these characters alone, the mineral might perhaps be mistaken for quartz, but as its specific gravity is not above 2·245, there can be but little doubt that we are here dealing with a species closely akin to tridymite, occurring under conditions altogether novel. The crystals are found in the hollows of the meteoric iron, where they are accompanied by pale-green prismatic crystals having a composition nearly agreeing with that of enstatite.

Two or three new American meteorites have been described by Professor C. U. Shepard.[‖] One of these is a meteoric iron, from Auburn, Macon Co., Alabama. Its chief peculiarity consists in its fissured structure, which gives it an appearance—to use the Professor's own words—"as if it had been shattered by striking when in a semi-fused state, against a rock, at the time of its fall." A description is also given of another meteoric iron, now in the St. Louis Academy of Sciences; and an analysis is published of the Losttown meteorite, previously noticed in this journal.* We have only space to give the percentages of the chief constituents in each specimen:—

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[*] 'Quart. Journ. Science,' v., p. 101.

[†] With sesquioxide of iron in the Cornish specimen.

[‡] Vol. ii., p. 635.

[§] 'Proc. Royal Society,' xvii., p. 370; 'Chem. News,' April 16, 1869.

[‖] Silliman's 'American Journal of Science,' xlvii., p. 230.

	Auburn.		St. Louis.		Losttown.
Iron	94·580	....	92·096	....	95·759
Nickel.. ..	3·015	....	2·604	....	3·660

When a polished section of meteoric iron is etched with an acid, it is well known that a peculiar crystalline structure is usually developed. The markings thus produced are known, after their discoverer, as the Widmannstätten figures. Dr. J. Lawrence Smith has recently found that certain meteorites from Trenton, Washington Co., Wisconsin, exhibit on similar treatment a distinct set of markings, different from those of Widmannstätten; and as his attention was first directed to them by a Mr. Lapham, he proposes to distinguish them as the *Laphamite figures.* The meteorites exhibiting these figures contained 91·03 per cent. of iron, and 7·2 of nickel.†

What is really the formula of that curiously-constituted mineral, *Haüyne?* On collecting the published analyses, it will be found difficult to reconcile their discrepancies. Dr. Kenngott has recently found that sulphate of soda may be obtained by the action of water on haüyne, and hence he believes that some of the recorded analyses have been made on specimens partially altered in this manner. Allowing for such an action, he regards the unchanged mineral to be constituted according to the following formula,‡ which indeed agrees with that deduced from Whitney's analysis of the Alban haüyne, namely:—

$$3\{(Na_2 \,.\, Al_2)\,0_4 \,.\, 2\,Si\,O_2\} + 2\,(Ca\,O \,.\, S\,O_3).$$

Further contributions to the mineralogy of Nova Scotia have been published by Dr. How.§ Among these will be found notices of a carboniferous lignite, from Pictou Co., and of the species Turgite, Delessite, and Fahlunite. A new locality is given for the interesting Acadian mineral described in a former number of this Journal under How's name of Silicoborocalcite,‖ but which has since been appropriately named *Howlite.*

In compliment to the well-known Italian geologist, Quintino

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* Vol. vi., p. 134.

† 'Silliman's Journal,' xlvii., p. 271.

‡ Leonhard und Bronn's Jahrbuch für Mineralogie. 1869, Heft 3, p. 329.

§ 'Phil. Mag.,' April, 1869, p. 264.

‖ Vol. v., p. 259.

Sella, the name of *Sellaite* has been appropriated to a new species described by Strüver.* The mineral is apparently a simple fluoride of magnesium, and crystallizes in small, transparent, prismatic forms, embedded in the anhydrite of Montiers in Savoy.

Associated with the cryolite of Ivigtok, in Greenland, a new species has been found, and named after the locality. *Ivigtite* appears to be a silicate of alumina, soda, and protoxide of iron, with a little fluorine.†

In a peculiar variety of hyperite occurring in the parish of Eura, in S. W. Finland, a mineral is met with, to which Herr Wiik applies the name of *Euralite.*‡ Its composition approaches that of delessite.

Professor Reichardt has recently published analyses of the *Polyhalite* which occurs in large nodular masses scattered through the so-called "polyhalite region" of the salt-deposits of Stassfurt, in Prussian Saxony.§

Picotite is a mineral bearing close kindred to spinel, and found in octohedral crystals in certain forms of olivine rock. Dr. Petersen has lately examined specimens from the Dun Mountain in New Zealand, and is thus led to establish two types of the species—a *chrome-picotite* and an *alumina-picotite.* The Doctor has likewise examined the *magnetic pyrites* of Auerbach, and regards its formula as FeS instead of Fe_7S_8, as generally written. Finally, he publishes some analyses of *red silver-ores,* both "dark" and "light," or in other words, both antimonial and arsenical.‖

10. MINING, METALLURGY, AND THEIR RECENT LITERATURE.

MINING.

In our last number we noticed the fact that the ancient Stannary Court of Cornwall was about to undergo a change, a Bill having been introduced for its amendment. Numerous alterations have been made in the Bill since its first reading; it has been read the second time; and no doubt, before these pages are in the hands of our readers, the Stannary Court Act will have become the law of the future for the Stannaries of Cornwall and Devonshire.

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* Atti della Reale Accademica delle Scienze di Torino.

† Silliman's Journal, xlvi., p. 400.

‡ Öfv. af Finska Vet. Soc. Förh. 1869, xi., p. 28.

§ Leonhard u. Bronn's Jahrbuch. 1869, Heft 3, p. 325.

‖ 'Journal für praktische Chemie,' 1869, No. 3, pp. 134, 137, 141.

The dues paid to the Stannary Court upon the ores raised within its jurisdiction have been for the last two years as follows:—

CORNWALL.

	1867.							1868.						
	Quantities.				Value.			Quantities.				Value.		
	Tons.	cwt.	qrs.	lbs.	£	s.	d.	Tons.	cwt.	qrs.	lbs.	£	s.	d.
Tin Ore . . .	10,848	9	3	27	538,006	19	4	11,216	18	0	22	621,083	1	5
Tin in Stone . .	140	0	0	0	7,230	17	7	201	0	0	0	11,162	9	11
Copper Ore . .	81,663	9	2	0	379,197	18	5	78,012	14	3	0	341,602	1	10
Lead Ore . . .	8,615	18	1	0	138,676	13	7	8,303	11	3	0	137,197	11	6
Zinc Ore . . .	1,674	6	0	0	4,097	1	9	1,852	7	0	0	4,921	1	1
Silver Ore . . .	—	—	—	—	—			—	5	3	18	10	19	3
Iron Pyrites . .	8,229	15	0	0	8,658	4	4	6,914	1	1	0	6,762	10	5
Arsenic . . .	1,200	0	0	0	2,074	11	2	1,267	4	3	0	3,608	19	10
Wolfram . . .	10	10	0	0	62	0	0	9	4	0	0	67	6	7
Ochre and Gossans	730	10	0	0	422	12	2	151	5	0	0	89	4	4
Nichel	1	17	1	0	14	12	5	—	—	—	—	—	—	
Fluor Spar . . .	—	—	—	—	—	—		60	0	0	0	42	0	0
Iron Ore . . .	5,418	10	0	0	1,675	16	1	6,545	11	0	0	1,994	1	6
Total . . .	118,533	5	3	27	1,080,117	6	10	114,534	3	2	12	1,128,541	7	8

DEVONSHIRE.

	1867.							1868.						
	Quantities.				Value.			Quantities.				Value.		
	Tons.	cwt.	qrs.	lbs.	£	s.	d.	Tons.	cwt.	qrs.	lbs.	£	s.	d.
Tin Ore . . .	78	8	0	14	4,137	10	2	54	3	2	13	3,085	17	7
Copper Ore . .	30,442	10	0	0	139,265	13	4	27,465	3	2	0	118,811	0	3
Lead Ore . . .	449	18	3	0	11,967	1	10	473	5	3	0	6,206	12	5
Iron Pyrites . .	646	6	1	0	353	17	7	685	3	3	0	496	14	6
Arsenic . . .	56	5	1	0	37	19	4	473	10	3	0	2,802	12	11
Ochre and Gossans.	33	18	0	0	39	7	3	27	2	2	0	62	10	10
Iron Ore . . .	7,396	1	0	0	2,277	11	9	3,563	17	0	0	1,069	3	1
Total . . .	39,103	7	1	14	158,079	1	3	32,742	6	3	13	132,534	11	7

It should be explained, that the above returns do not represent the actual total production of the mines of the two western counties, which are comprehended within the Stannaries. They do so very nearly; but it generally happens that some of the less important mines do not make their returns for some time after the termination of the year. The quantity of arsenic produced in 1868, being nearly 420 tons more than that obtained in 1867, should be explained. It arises entirely from the extensive and very complete arrangement made at the Devon Great Consolidated Mines, near Tavistock, for subliming the arsenic from the vast heaps of Arsenical Pyrites which have accumulated on their floors.

"A Bill to Consolidate and Amend the Acts relating to the Regulation and Inspection of Mines" has been introduced to the House of Commons by Mr. Secretary Bruce and Mr. Knatchbull-Hugessen, and read a second time.

In its present form the Bill does not appear to satisfy any one. The coal-owners and the coal-workers equally complain. On the one hand, the owners feel aggrieved at the additional responsibilities which are thrown upon them; and on the other, the colliers say they receive no more real protection by this Bill than they did under the old Inspection Acts. The Mining Association of Great Britain is meeting from time to time to watch the progress of matters affecting the interests of the coal trade, and sundry amendments have been proposed to the Government by that body. The working colliers have also had several meetings, and, by their delegates, they urge the Government to appoint additional inspectors, or to create a class of sub-inspectors.

The principal novelty in this Bill is the clause making it compulsory that plans of all abandoned collieries should be lodged with the Secretary of State, within three months from the time when the coal within the pit has been abandoned. There appears to be some difficulty in the way of carrying out this excellent provision. It is thought that the plans so deposited may be used to the injury of the individual. This, however, may be guarded against, by enacting that such plans shall not be evidence in a court of law, and that no action can be founded on evidence obtained by inspecting those plans or maps. As a means of protecting the lives of the miners, it is important that all information respecting our subterranean workings should be preserved. It is therefore to be hoped that this clause may, with well-considered restrictions, become a portion of the new Inspection Act.

COAL.—The production of coal in these islands was in 1867, according to the returns given in the "Mineral Statistics," 104,500,480 tons. In 1868, according to the returns of the Inspectors of Coal Mines, the quantity was 104,566,959 tons. Of this the exports, according to the returns of the Board of Trade, were as follows:—

NAME OF COUNTRY.	Quantity.	Declared Value.
	Tons.	£
Russia	623,767	306,103
Sweden	336,099	162,971
Denmark	835,669	367,721
Prussia	583,450	239,101
Hanse Towns	767,744	346,393
Holland	260,048	126,004
France	1,925,370	872,492
Spain and Canaries	524,161	294,248
Italy—Sardinia	288,852	145,590
United States	103,851	72,046
Brazil	293,577	172,393
British India	542,570	293,003
Other countries	3,752,355	1,957,726
Total	10,837,513	5,355,791

The report of the Colliery Inspectors for 1868 has been recently published. The following table has been compiled from that document:—

A Return showing the Quantity of Coal Raised in and about the Coal Mines of Great Britain; the Number of Fatal Accidents and Lives Lost by the Accidents, in the Year 1868.

Names of Districts.	Number of Collieries.	Quantity of Coal Raised.	Separate Fatal Accidents.	Lives Lost by the Accidents.
		Tons.		
Northumberland, Cumberland, & North Durham	175	11,400,000	67	69
South Durham	171	15,300,000	84	87
North and East Lancashire	292	7,053,000	61	65
West Lancashire and North Wales ..	208	7,600,000	126	237
Yorkshire	459	9,705,000	77	80
Derby, Nottingham, Leicester, and Warwickshire	195	7,699,000	58	60
North Stafford, Cheshire, & Shropshire	225	6,000,000	57	61
South Stafford and Worcestershire ..	550	9,900,000	90	104
Monmouth, Gloucester, Somerset, and Devonshire	230	6,200,000	59	61
South Wales	329	9,000,000	100	104
Totals: England and Wales	2834	89,857,000	779	928
East Scotland	254	8,456,084	41	43
West Scotland	203	6,253,875	40	40
Totals: Scotland	457	14,709,959	81	83
Totals: England, Wales, & Scotland	3291	104,566,959	860	1011

It should be noted that all the collieries given were not at work in 1868—from two to three hundred were probably idle; we may therefore consider the number of working collieries at about 3000.

The imports of Coal and Coke to France were, according to official French returns in 1868:—

	Coals.	Coke.
	Tons.	Tons.
From Great Britain	1,885,000	3,800
„ Belgium	3,718,000	448,200
„ Germany	1,389,000	212,700
„ Other Countries ..	1,000	300
Totals	6,993,000	665,000

Mineral Oils.—M. St. Claire-Deville has recently brought before the *Académie des Sciences* a most useful memoir on the calorific value of the mineral oils, the result of a series of experiments which he has carried out by order of the Emperor. The results to which these experimental trials have led this eminent chemist are—

"En général, cette chaleur est plus faible que celle qu'on calcule par la loi de Dulong, et les chaleurs de combustion de l'hydrogène et du carbone déterminées par MM. Favre et Silbermann, si l'on opère sur les huiles non oxygénées. Au contraire, pour des huiles fortement oxygénées comme de l'huile de houille, on trouve une chaleur plus grande que la chaleur calculée par la loi de Dulong. Ces limites seraient donc dans la catégorie des corps explosifs qui contiennent plus de chaleur que les éléments qui les constituent n'en possèdent à l'état isolé."

The distillation of oils from the bituminous shales and cannel coals of this country has within the past quarter shown a disposition to revival. The influx of American oils entirely stopped the production of oils in these islands, by reducing the price. The demand for the mineral oils and paraffin is increasing, prices are advancing, and consequently, in many places, fires are being relighted under retorts which have been for the last two years in a state of repose.

GOLD.—The quantity of gold raised during the first quarter of this year at Vigra and Clogau, in Merionethshire has been somewhat in excess of that produced in the corresponding quarter of last year. Some other quartz lodes have been opened on in the Dolgelly district with very promising results.

With the approach of fine weather the Helmsdale diggings in Sutherlandshire have attracted a large number of miners. An interesting popular account of those "diggings" has been written by J. F. Campbell, Esq., of Islay, called 'Something from the Gold Diggings in Sutherland.' Mr. Campbell states "that more than 290 men are paying a pound a month for leave to camp out and work like navvies in claims of 40 feet square; so that they must be earning wages or going crazy." From the best authority we are enabled to state that about 2000*l.* worth of gold has been found since the Helmsdale burns have attracted attention.

Platinum has been, according to the 'Mining Journal,' discovered in Scotland. It is said to have been found in some auriferous Scotch quartz, and, as we glean, in connection with the gold deposits which have been exciting attention. We are disposed to think this to be very problematical, and await some further information. That some very minute particles of platinum were found in the auriferous sands of Wicklow, some years since, is certain, but no quartz in the British Isles has ever yet been found to contain that metal.

Gold is reported to have been found in considerable quantities in the region of the Cape of Good Hope, mainly in the great plateau north of the Sneeuwbergen to the Orange river. Although some doubts have been thrown on the discovery of diamonds at the Cape, it appears tolerably certain that about thirty of those valuable gems have been found. Dr. Muskett, of Hope Town, writing to the Society of Arts, says the formation in which those gems are found "consists of rolled quartz, pebbles of various sorts, chalcedony, agates, quartz crystals, bloodstone, Lydian stone, &c., fixed in a matrix of sandstone, and it rests on a regular sandstone formation."

The Miners' Association of Cornwall and Devonshire has just issued its annual report. From this it appears that in 1868 fifty-one students in the classes passed the examinations of the Department of Science and Art. The Rev. Saltren Rogers, one of the Vice-Presidents, states:—"The pupils have been gathered partly from working miners; more from a class above them, sons of mine agents, shopkeepers, schoolmasters, and the like. Though it might be wished that a larger proportion of the former were among our pupils, it is nevertheless very important that a stimulus to scientific studies should be given among the latter; it is through them, and not through the working miner, that we must look for a higher and more general appreciation of such studies; it is from men that have had the preparatory elementary education which they have had, that we may expect inventive genius, which may be of the highest practical value. It is a fact that becomes more and more undeniable, that most of our working miners leave school at too early an age to have their powers sufficiently developed to master the elements of science; many of them cannot write correctly, or understand the simplest terms without explanation, or work a sum in proportion; and without this amount of preparation the simplest *sound* scientific training must be lost upon them. We have, however, commenced an experiment this year, which is as yet too recent to enable us to form a judgment as to its success, which will, we trust, bring down our teaching to the level of a slightly lower capacity than that to which it has hitherto been adapted; I refer to the formation of sub-classes, of which those who have passed well in the South Kensington Examinations are teachers; the course being longer and simpler than those conducted by our official lecturer. These sub-classes are still under his superintendence, and he is instructed from time to time to test the efficiency of the work by examinations of the pupils; five of our more advanced pupils are now conducting sub-classes of this kind."

There has been some talk about attempting to establish a mining school in South Wales; and there is some stir amongst the supporters of the mining school at Glasgow—which was allowed to die a few years since—in the hope that they may be in a position to revive it. Dr. Bryce, the President of the Philosophical Society of Glasgow, has been in correspondence with Mr. Mark Fryar, now Mining Engineer for the Indian Government, and some of the remarks made by Mr. Fryar, who was for upwards of four years the teacher in the old Glasgow school, are worthy of all attention.

"It is absolutely necessary that some arrangement be made for enabling young men to give up a portion of their work in the mines during the time of their attendance to lessons or lectures. Men or boys cannot be expected to profit much from any source of instruction after having done an ordinary day's work in a mine. I have been all my lifetime among miners, and know them well, and many a hard day's work I have done myself in mines, and I can assure you that schools of mines and scientific lectures are of no manner of use to the working miner, unless he has too the means of subsisting on about half the usual amount of labour he is expected to perform; and so physically prepare himself for mental work, and for handling the instruments used in mapping and drawing."

There is much truth in the suggestion that hard labour is not compatible with attentive study, and that those men who exhibit a thirst for knowledge should be placed in a position to acquire it, is to be desired. In considering the possibility of educating the working miner we must, however, remember that it is only with the best of their class that we shall ever have to deal. That those young and earnest men will generally succeed in placing themselves in some superior position, which will give them the required period, not of leisure, but of cessation from actual toil. Mining schools, wherever established, will only secure as satisfactory students those who have already made a mental resolve to raise themselves above their brethren. Experience has shown that mining schools in Glasgow, in Bristol, in Wigan, in Truro must be failures. It is quite as difficult for working miners to attend the classes in any one of those cities or towns, as it would be for them to attend the courses of the Royal School of Mines in London.

No system of education can be of any advantage to our mining population which is not an itinerating system. The classes must be formed in the centre of groups of mines, the instruction must be taken to the miner, since it has been proved impossible for the miner to come to the instructor.

METALLURGY.

WOLFRAM.—In the *Académie des Sciences,* M. La Guen, a captain of artillery, has called attention anew to the remarkable properties imparted to Bessemer steel by the addition of a small quantity of tungsten. The question was put, could wolfram, allied, as it is, to the ores of tin, be obtained at a sufficiently low price to be employed with economy? We may answer this by stating that large quantities of this mineral can be obtained at East Pool Mine in Cornwall; and that at Drake Wales, Kit Hill, and some other tin mines, it could be procured at a cheap rate, if the demand became sufficiently large to warrant its extraction.

IRON AND ZINC.—Although it has long been known that iron would dissolve in molten zinc; it has not hitherto been determined whether there was any definite alloy of those metals or not. We find in Erdmann's Journal of 'Practical Chemistry,' an account of an alloy in which the metals do appear to exist in definite proportions, its formulæ being given as $Fe\,Zn\,36$ ($Fe = 56$; $Zn\,32 \cdot 75$). The physical aspect of the alloy was very different from that of zinc; it was whiter in colour and possessed a different crystalline structure; it contained 4·6 per cent. of iron.

COKE.—The importance of obtaining coke free from sulphur cannot, especially for iron manufacture, be over-estimated. Numerous experiments have, from time to time, been made, with a view to the use of coal in which some pyrites occur, in the manufacture of a pure coke for the blast furnace.

Some experiments have been made in France which are stated to have been remarkably successful. The coke when at a temperature of 300° Cent. was submitted to a strong current of atmospheric air strongly compressed. This current of air is said to convert the sulphur into sulphuric acid and remove it. The coke is reported to produce iron equal to that which has been made with wood charcoal.

ALUMINIUM.—The American journals announce that Mr. A. L. Fleury, of Boston, has succeeded by a new process in smelting alumina. He mixes pure alumina with gas tar or petroleum, and forming the mixture into pellets, which are dried, they are placed in a strong retort which is lined with plumbago. Into this carburetted hydrogen gas is forced until the pressure is from 25 lbs. to 30 lbs. on the square inch. The aluminium is reduced, and remains as a spongy mass, mixed with carbon. This is remelted with metallic zinc, and the zinc being volatilized, a pure mass of aluminium remains behind. About four hours are required for reducing a hundred-weight of alumina.

Refined Iron.—Mr. Ellershausen has been carrying out some experiments, which appear to us to be new only in the method adopted, at the iron-works of Shoenberger at Pittsburg, U.S., on the conversion of crude cast-iron, as it runs from the blast furnace into wrought-iron of fine quality, by the admixture of iron ore. It has long been known that an oxide of iron will combine with and remove the carbon from pig-iron. The 'American Artizan' describes the process, which appears to consist in allowing a quantity of very finely powdered peroxide of iron to flow into boxes prepared to receive it, at the same time as the iron is allowed to flow into them from the furnace. The mass thus formed is submitted to the subsequent process of puddling, and it is said that merchant iron is produced at the first rolling, thus considerably reducing the cost.

The chemists have of late been turning their attention to the character of iron in its different varieties. Dr. Miller, of King's College, has made some useful analyses of that produced by the Heaton process. Dr. Paul has read before the Chemical Society a paper "On the Connection between the Mechanical Qualities of Malleable Iron and Steel, and the Amount of Phosphorus they contain;" while Mr. Arthur H. Elliott has a paper "On the Determination of the 'Total Carbon' in Cast Iron." Mr. J. Lowthian Bell, the well-known iron-master of Cleveland, has lectured (May 6th) before the Chemical Society "On the Chemistry of the Blast Furnace." In this lecture a very careful consideration of all the conditions under which the changes occur in the blast furnace was brought before the chemists. This union of the experience of a thoroughly practical man with the theoretical knowledge of the scientific chemist cannot fail to have its advantages.

At the present time, attention is turned with so much earnestness to the economy of coal in the production of iron and steel that we may anticipate ere long to hear of the realization of results which have hitherto been thought to be highly problematical.

Bronzes.—The production of a fine *patina* on our bronze statues instead of a coating of dust and soot is, especially in our large cities, a thing to be desired. In Poggendorff's 'Annalen' for April we find the report of a series of experiments which were made by direction of the Berlin Verein zur Beförderung des Gewerbfleisses, to examine into the causes determining the formation of this *vert antique* patina, on bronze statues.

The experiments while in progress led the observers to suppose that grease had much to do with the formation of the finest patina. Four busts were therefore placed in a part of the town which was very unfavourable. One of them was rinsed every day, with the exception of rainy days, and was painted once a month with bone oil, which was at once rubbed off with woollen cloths. Another bust was washed daily, but not oiled. A third was cleaned daily, but oiled only twice a-year. The fourth was not at all touched. These experiments have been continued for four or five years. The result is that the bust which has been oiled once a-month possesses a dark-green patina, which is considered to be very beautiful by connoisseurs. The bust which has been rubbed twice a-year does not look so well. The others have no patina. The bust which has been washed regularly is the usual dull bronze colour. The other is quite dull and black. The final result of those who have been engaged in the experiments is, this use of oil justifies the hope that for the future we may retain beautifully patinated monuments, even in large towns. Where coal is the only combustible they will not be bright, but dark-green, and perhaps even black; but they will have the other beautiful property of the patina, the peculiar transparent condition of the surface.

We have recently received the following works which are directly connected with the production of those minerals which are of commercial value:—

'*Annuaire de l'Association des Ingénieurs sortis de l'Ecole de Liége.*' This gives a very complete study of the coal basin of Liege.

'*Les Houillères en* 1868,' being the Report of Amédée Burat, the Secretary to the Society of French Coal Owners. The present position of the coal trade of France is very clearly stated. Some comparisons are drawn between the modes of working the French collieries and those of Great Britain, in which the author is disposed to look upon the system adopted in his own country as superior to that which is adopted in England and Wales. The comparisons are not fairly drawn; there are doubtless isolated cases where great carelessness exists, but generally the utmost amount of care is found to prevail in our collieries.

'*The Mineralogy of Nova Scotia*' is a Report of the Provincial Government, by Dr. Henry How. It gives such a general view of the mineral resources of the Province, as will show what has actually been done in the working of its best known treasures, —coal, gold, iron, gypsum, and building stones. This report is executed with great care, and gives such statistical details as cannot fail to be of great utility to all who are in any way concerned in the mineral resources of this most interesting colony.

A recent work bearing on Metallurgy is noticed in our Chronicle of Engineering.

11. PHYSICS.

Light.—The Rev. Father Secchi has made an interesting observation on the light emitted from the planet Uranus. This light, it appears, differs from that of the rest of the planets belonging to our solar system. Its spectrum exhibits broad absorption lines, so that the yellow colour is almost entirely absorbed. While it is clear that the light emitted by this planet is reflected light from our sun, it is evident that the surface of the planet modifies that light in the same manner as do coloured bodies.

Mr. Crookes has recently sent a paper to the Royal Society, in which he describes a spectrum-microscope which he has devised in order to obviate the disadvantages of the ordinary instrument. The principal features of the new apparatus are the sub-stage and the box of prisms. The former carries a sliding-plate to hold the slit and apertures, a spring stop and screws for adjusting them, and a reversed object-glass. The slit and this object-glass are about 2 inches apart, and if reflected light is passed along the axis of the instrument, the object-glass forms a very small image of the slit in front of it. The direct-vision prisms consist of three flint and two crown, fitted in a box screwed into the end of the microscope. By means of a pin they are thrown in or out of action. The object-glass screws on in front of the prism box. By taking the illumination from the sky or a white cloud, Fraünhofer's lines are visible, and by direct sunlight they are seen in great perfection; the dispersion is sufficient to cause the spectrum to cover the whole field, and the achromatism of the lenses being nearly perfect, the lines from B to G are practically in the same focus. When the light is good, the appearance of the spectrum, and the power of grasping faint lines, are greatly improved by dividing the light with a Wenham prism, and using both eyes; whilst the stereoscopic effect thereby communicated to some absorption and interference spectra, throws a new light on the phenomena.

By using a spirit-lamp instead of the illuminating lamp, the instrument answers admirably for examining flame spectra. The characteristic yellow, crimson, or green lines are seen beautifully sharp, on introducing sodium, lithium, or thallium into the flame.

By means of this spectrum-microscope Mr. Crookes has observed some curious optical phenomena of opals.

If an opal which emits a fine broad crimson light is held in front of the slit of a spectroscope, or spectrum-microscope, at the proper angle, and the source of light is moved so as to shine into the spectrum apparatus through the opal, the appearance is observed of a luminous spectrum with a jet black absorption band in the red.

From these and other experiments it has been found that those parts of the opal which emit red, yellow, green, or blue light are opaque to light of the same refrangibility which they emit. The appearances of some opals examined in this way are very striking. In the next number of the 'Quarterly Journal of Science' Mr. Crookes will describe these and other kindred phenomena more fully, but we may briefly allude to the following curious spectra which have been observed:—

Some opals show a simple black band in the red, which when in focus has a spiral structure. Examined with both eyes, it bears a resemblance to a twisted column.

In another opal, which gives an irregular line in the orange, the spiral structure is shown in a marked manner, the different depths and distances standing well out; upon carrying the opal slowly from left to right, the line is seen to revolve and roll over, altering its shape and its position in the spectrum. It is not easy to retain the conviction that one is looking merely at an absorption band in the spectrum, and not at a solid body possessing dimensions, and in actual motion. Other opals show an absorption band travelling along the spectrum, almost from one end to the other, as the opal is moved sideways.

M. Soret, in consequence of Professor Tyndall's note "On the Clouds," has examined, by means of the polariscope, the beautiful blue colour exhibited by many parts of the Lake of Geneva, and he states that this colour is due to the presence of solid particles in the water, of the same specific gravity as that fluid; but he does not say what these particles are, nor what size or shape they have; promising, however, further researches.

In order to answer the often-doubted fact of the decomposition of carbonic acid under the influence of light, and the separation of oxygen by the leaves of plants, Boussingault has introduced into mixtures of carbonic acid gas and hydrogen, and the former gas and nitrogen, first a clean stick of phosphorus; as long as no oxygen is present, this element does not undergo slow combustion, thereby giving off vapours; but as soon as a green leaf of any plant was carefully brought into the gaseous mixtures standing over mercury, the slow combustion of the phosphorus began, owing to the decomposition of the carbonic acid and formation of oxygen; this action takes place also in diffused daylight, but not during twilight; leaves wherein the chlorophyl is not fully developed do not act in this manner.

It is a well-known fact that, even independent of the effects of rain and wind, glass, even of good quality, is affected by sunlight. The late Dr. Faraday made some observations concerning this subject, and found that violet-coloured glass became deeper and more intensely coloured than it originally was, after having been exposed to direct sunlight for eight months. M. Graffield, of Botson, U. S., who has been for more than twenty years in the wholesale glass trade, and is at the same time a good observer, has recently sent to the Photographic Society of Marseilles a series of the results of his researches and observations on this subject, in which he comes to the conclusion (which is especially important to photographers) that glass is even sensibly affected after one single day's exposure to the sun's rays, and that all glass, without exception, including that used for optical purposes, is more or less acted upon, even when made from the best materials and by most experienced workmen; greenish glass seems to become the least affected. The author has sent to Marseilles a series of photographs representing the tinge and changes produced in divers varieties and kinds of glass after exposing them to sunlight.

Many of our readers have had the opportunity of noticing that bottles, especially if made of white glass, containing disulphide of carbon often become lined, if exposed for any length of time to direct sunlight, with a coating strongly adhering to the glass. M. Loew has experimented on this substance, by enclosing the disulphide in sealed glass tubes previously moistened with water, which has the effect of lessening the adhesiveness of the brownish coating. On opening the sealed tubes after a few months' exposure to sunlight, the water was observed to have an acid reaction, due to the formation of some formic acid. The solid substance alluded to is insoluble in alcohol, chloroform, ether, and disulphide of carbon, but soluble in a boiling solution of caustic potassa, becoming, however, at the same time decomposed. It has the composition of sesquisulphide of carbon, and on being submitted to distillation is decomposed, yielding sulphur and carbon. The disulphide of carbon from which this substance is deposited contains sulphur in solution, although it was perfectly pure previous to exposure to sunlight.

When freshly-precipitated chloride of silver (best obtained by decomposing a soluble silver salt with chlorine-water) is placed in a white-glass tube about 15 inches in length, and exposed to the action of direct sunlight, it will be observed that the chloride of silver remains quite white as long as the solution of chlorine-water retains its greenish-yellow colour; but as soon as that colour has vanished, the chloride of silver begins to decompose water under the influence of the direct rays of sunlight; the chloride gradually blackens, and after a shorter or longer duration of time, the whole quantity will have become black, especially if care be taken to shake the tube now and then, so as to expose the whole mass to the light. When the tube is afterwards placed in a dark place, entirely excluded from daylight, the black colour of the chloride of silver again disappears gradually, and the chloride becomes white. This experiment can be repeated over and over again with the same tube. The bromide, and probably also the cyanide of silver, behave in the same manner; the iodide of silver blackens only after having been rendered sensitive to light by pyrogallic acid.

Dr. Thudicum has recently published some investigations on Luteine. By luteine Dr. Thudicum understands a yellow crystalline substance occurring in various parts of animals and plants, as, for instance, the *corpora lutea* of ovaries, serum of blood, yolks of eggs, in seeds, as maize (Indian corn), in annatto, in carrots, and the stamina and petals of a great many flowers. Luteine is easily soluble in alcohol, ether, and chloroform; insoluble in water. These solutions are yellow; but that in chloroform, when concentrated, has an orange-red colour. The spectrum of its solutions is distinguished by great brilliancy of the red, yellow, and green part, and by three absorption bands, which are situated in the blue, indigo, and violet part of the spectrum. The crystals of luteine are apparently rhombic plates, of which two or more are always superposed in a curious manner. The crystals are microscopic yellow when thin, orange to red when thick, and have no resemblance to any other known animal or vegetable substance. Luteine combines with few substances, mercury-acetate being perhaps the only reagent by which it is immediately and completely precipitated as a yellow deposit; mercury-nitrate produces a yellow precipitate, which on standing becomes white. Nitric acid, poured over the crystals, produces a blue colour, which immediately passes into yellow. The blue is not produced when nitric acid is added to either the alcoholic, ethereal, or chloroformic solution of luteine, but appears with the acetic-acid solution, and disappears again rapidly. Luteine has great affinity for fatty matters and for albumen.

The Paris correspondent of the 'British Journal of Photography' reports that the oxyhydrogen-zirconia light has been such a success at the Tuileries, having been worked without interruption since the 21st of January, that the Emperor has ordered measures to be taken to render that mode of illumination permanent in front of his palace. In connection with this fact, we may mention that M. Tessié de Mothay has had the Order of Chevalier of the Legion of Honour bestowed upon him. The learned Abbé Moigno, while referring to this subject in '*Les Mondes,*' says, "Our readers will undoubtedly hear with pleasure that the production of oxygen in a cheap manner from manganate of potassa, and that of pure hydrogen, by means of a hydrocarbon fuel on the large scale, have become a decided success; that moreover, the reduction of the earths baryta, magnesia, and alumina to the metals barium, magnesium, and aluminium, by means of hydrogen under high pressure and a very high temperature, is successfully carried out; while lastly M. Caron has succeeded in obtaining, by means of great perseverance, zircon-magnesia cones, which, instead of being very breakable and only lasting for a few nights, are fit for use for any length of time."

Mr. D. Winstanley has described an apparatus for obtaining a light from the combustion of disulphide of carbon. It consists of a water-bath, heated by a Bunsen gas-burner. Within the water-bath is placed a vessel to hold disulphide of carbon. The outer and inner vessels are firmly soldered together, and proper arrangements are made to enable the experimenter to pour water in the outer vessel, which is also provided with a neck to hold a thermometer, serving to indicate when the temperature at which the disulphide of carbon contained in the inner vessel boils. The inner vessel is provided with a neck, closed by a well-fitting cap when the apparatus is in use, for the introduction of the fluid disulphide of carbon. Besides this, there is soldered to the inner vessel a gas-pipe of small bore, which pipe projects at a convenient height above the outer vessel. To this pipe is soldered and connected at right angles another pipe provided with a stopcock, and further connected, by means of elastic tubing, with a gas-holder containing oxygen gas made from chlorate of potash. After the application of gas-flame beneath the water-bath, the thermometer is watched until it indicates that the vapour of the bisulphide of carbon is issuing from the burner (from the gas-pipe connected with the inner vessel); the heat is allowed to continue beneath the water-bath until the flame reaches the flaring point, when it is lessened almost to extinction. The oxygen gas is then cautiously introduced, upon which the flame at once diminishes in size and increases greatly in brilliancy. This light is proposed for use in photography, on account of its great actinism: as a source of intense heat it may also perhaps be recommended.

Heat.—While engaged in other studies on geology in the southern parts of France, M. Andouin found that between Tarascon and Antibes there exists a very valuable and extensive bed of *bauxite* (hydrate of alumina), which is occasionally applied for the manufacture of sulphate of alumina. This material has been applied at his suggestion for the manufacture of crucibles and fire-bricks; and on having been tested in comparison with the best products of the kind from France, England, and Germany, it was found that even best fire-bricks might be melted in bauxite-made crucibles, heated by mineral oils and a blast.

In reference to the well-established fact that water, after having been deprived of air as much as possible, either does not boil at all when heated, or does so with violent sudden starts and concussions, some experiments have been made by Kremers, who observed that, in order to assist in expelling air from water, the addition of spirits of wine, in the proportion of one part of the latter to three of the former, is very useful. He cautions against a danger which exists when such a mixture is heated too rapidly; since it is very apt to boil over, especially after a portion of the spirit has evaporated. It is rather curious that, though both the water and spirits of wine employed were pure, the mixture when boiling should assume a greenish-yellow hue, which disappears again on cooling. The boiling-point of the fluid easily becomes as high as 109°. As a result of a large number of experiments, the author finds that water, as fully deprived of air as possible, may be heated as high as from 180° to 200° C., without boiling permanently.

M. Debray has investigated the action of heat upon the peroxide salts of iron. In a large portion of distilled water a few drops of a *neutral* solution of chloride of iron are poured, care being taken not to apply so much of the salt that its colour is imparted to the water; on heating the liquid gradually up to, and above, 70° C., it becomes perceptibly brown-coloured. When this moment has arrived, the water no longer contains chloride of iron, but instead a mixture of free hydrochloric acid and free peroxide of iron; the limpidity of the fluid is not, however, at all impaired. In order to prove this, it is only requisite to pour into the fluid a solution of common salt, whereby the static equilibrium of the liquid is disturbed, and the oxide of iron precipitated. When the experiment is made in sealed tubes, and the latter heated to between 200° and 300° C., crystalline oxide of iron is precipitated.

A new freezing mixture, which appears to be of considerable interest, has been described by Mr. Galletly. When citric acid and crystallized carbonate of soda, in powder, are stirred together, the mass gets into a pasty state, and in a short time becomes quite liquid. If equivalent proportions of the substances are used, the temperature falls from 60° F. to -8° F. The mixture for a time is full of air-bubbles, but soon becomes a clear, dense, syrupy fluid. The fluid obtained by mixing the powders becomes solid in a day or two standing in a corked jar. The solid mass has the appearance of set plaster of Paris or damp chalk. The addition of a very little water appears to prevent this setting into a solid mass; but the chalky-looking citrate lies a long time in cold water without being dissolved.

Dr. H. Fleck, of Dresden, has instituted a series of experiments with a view to obtain a non-poisonous paste for application to lucifer-matches. He ascertained by some preliminary experiments that sodium, when minutely divided along with explosive substances, becomes highly inflammable when simply moistened with water. A mixture was made of

0·5	grammes of	sodium,
66·0	„	nitrate of potash,
36·5	„	sulphide of antimony.

Provided that during its manufacture this mixture is kept thoroughly dry, it has been found to answer admirably well. According to several accounts from Germany, this plan of substituting sodium for phosphorus has been favourably taken up by some of the largest leading manufacturers of lucifer and fusee matches. There is said to be not the least danger in the transport.

It is well known that various accidents occur from fire caused by persons carelessly throwing down matches, which they believe to be harmless because the flame has been extinguished, but which, in reality, are highly dangerous, and quite capable of communicating fire to any light dry material, in consequence of the wood-splint being at a red heat, although not actually in flame. It appears from the 'Scientific American' that it has been proposed, in order to prevent this, to saturate the splints, previously to their being dipped, with a solution of some chemical salt which has the property of preventing the wood from remaining at a red heat after the flame has been extinguished without being in any way detrimental to the inflammable nature of the splint, and thus to prevent the possibility of accident from the dropping of the match after the extinction of the flame, but while the splint is still at a red heat. The substance which it is proposed to employ is alum, though other salts have the same property. The matches before being dipped are to be immersed in a strong solution of alum, or other salt with a similar action, until they are saturated; they are then to be dried and tipped with the ordinary composition. Matches, so treated, are said to ignite, and burn with flame as long and readily as other matches; but the instant the flame is blown out, the match becomes black and perfectly harmless.

Electricity.—By far the most gigantic electrical instrument ever made has just been fitted up at the Royal Polytechnic Institution. This is the large induction-coil, which has been made by Mr. Apps. It is 10 feet long and 2 feet in diameter. The core of soft iron weighs 123 lbs., and consists of wires each 5 feet long and 0·0625 in diameter. The primary coil weighs 145 lbs., and is composed of 3770 yards of copper wire. The secondary wire is 150 miles in length, and 0·015 inch in diameter. The galvanic current for the primary coil is supplied by 40 of Bunsen's cells. It is capable of producing a spark 29 inches long, and the flash will perforate plate-glass 5 inches thick. This huge and powerful coil will not only be valuable to Professor Pepper to illustrate the wonders of electricity to the general public, but it has already been placed by him at the disposal of Dr. Richardson and other scientific men as a means of promoting scientific research.

Dr. Sarrazin has noticed some hitherto unknown phenomena of phosphorescence. As soon as pure oxygen is reduced to a pressure of only two millimetres or less, it becomes exceedingly luminous under the influence of electricity. No other known gas is possessed of this property. All compound gases which contain oxygen become also luminous, and most so the protoxide of nitrogen. The doctor has found that the cause of this phosphorescence is due to the formation of ozone, since it does not take place when, previous to passing an electric current through the gas, powdered metallic silver has been introduced into the space containing the gas; in this case the silver becomes rapidly oxidized.

While engaged in studying the part which sulphuric acid plays in these phenomena, Dr. Sarrazin found that when a small quantity of this acid, which is considered non-volatile at ordinary temperatures, was confined along with nitrogen gas, for instance, in a gas jar, and an electric current passed through, a very intense luminosity was caused, notwithstanding nitrogen is not by itself rendered luminous under these conditions. The author found that there was decomposition of sulphuric acid, with formation of ozone, and that the phenomena ceased when powdered silver was introduced.

Mr. Freidel has quite recently discovered that silicated hydrogen gas is entirely decomposed by the electric spark, giving rise in the endiometer to a shower of amorphous silicium of a brown colour.

A phono-electroscope has lately been described by Mr. Edwin Smith, M.A., for the purpose of illustrating the heating power of the voltaic current. It consists of a rectangular wooden box, 10 inches by 5, two steel or platinum wires stretched from end to end, a small spindle carrying two quill plectra, and an eccentric wheel for making and breaking the current through one of the wires. The wheel turns under a brass spring, which plays upon a button. The spring is connected with one electrode of the battery, the button with the wire nearest to it, and this wire with the other electrode. To exhibit the use of the instrument: first, tighten the wires by means of milled-headed screws, to unison, to about the pitch of middle C; then turn the spindle so as to sound the two notes in succession *before* the eccentric wheel makes the circuit. After these have unison, turn the spindle a little more; the circuit is made by wheel and spring, and presently the plectra are allowed to play a second time on the wires, which now sound, with an interval of a tone or more, according to the quantity of electricity which has passed through one of them. By regulating the time between the instant when the wires sound in unison and the instant when they sound again, and noticing the musical interval caused by one of them becoming flat, we have an audible measure of the expansion of the connected wire, of the temperature to which it has been raised, and of the quantity of electricity which has traversed it to produce that effect. By continuing the movement, the interval between the notes will increase, and at last the wire operated on will become too slack to sound at all. If connection with the battery be now broken, and the heated wire be allowed to cool, its note will be heard to rise by degrees to its original pitch. With a single pair of plates, the phono-electroscope answers well. The experiment is a striking one in a lecture-room, very instructive, and easily managed.

According to Böttger, the metal antimony may replace graphite in galvanic batteries. He finds the following arrangement preferable, as regards force and durability, to either Daniell, Minotto, or Leblanche's batteries. A cylinder of amalgamated zinc is placed in a concentrated solution of equal parts of common salt and sulphate of magnesia; the antimony is placed in a porous cell filled with dilute sulphuric acid.

Mr. Gore, F.R.S., whilst making some experiments on heating strained iron to redness by means of voltaic electricty, observed that, on disconnecting the battery and allowing the wire to cool, during the process of cooling the wire suddenly elongated, and then gradually shortened until it became quite cold. The amount of elongation of the wire during the momentary molecular change was usually about 1-240th part of the length of the heated wire; the molecular change evidently includes a diminution of cohesion at a particular temperature during the process of cooling, and it is interesting to notice that at the same temperature during the heating process no such loss of cohesion, nor any increase of cohesion takes place; a certain temperature and strain are therefore not alone sufficient to produce it, but the condition of cooling must also be included.

M. Alvergniat calls attention to the fact, that by simply rubbing one of Geissler's tubes with the dry hand or a piece of silk, it exhibits the same phenomena of luminosity as if induced by electricity; the phosphorescence is, however, weak, but may be increased when within the tube substances are deposited which may become phosphorescent under the influence of electricity; when a tube so arranged is quickly rubbed, it becomes within a few moments sufficiently luminous to serve as a faint light to see in a dark room.

12. ZOOLOGY—ANIMAL MORPHOLOGY AND PHYSIOLOGY; AND RECENT LITERATURE.

MORPHOLOGY.

New Views on the Homologies of the Suspensorium.—The advanced school of osteologists—that is to say, those who reject the vertebral theory of the skull—originated by Oken and Goethe and developed by Carus, have been in the habit of pointing to the *ossicula auditûs* as the homologues of the quadrate and articular pieces, the incus being regarded as the homologue of the former, the malleus as that of the latter. The relations of the chorda tympani to these bones, though said to support this interpretation, did not really do so; and many powerful arguments were urged against it by Professor Peters of Berlin, Professor Humphry of Cambridge, and others. Professor Huxley, who is chiefly responsible for the view in this country, has re-examined the matter, and has been led to a much more satisfactory conclusion, especially from the study of that very remarkable lizard, the *Hatteria, rhyncocephalus*, or *Sphenodon* of New Zealand. Instead of now regarding the incus as the homologue of the quadrate, he considers it to form part of the second visceral arch, and to be represented in Birds and Reptiles by a ligament or a cartilage connected with the stapes. He regards the malleus as the representative of the quadrate, the articulare of the lower Vertebrata not being represented by bone in the Mammalia. In Fishes he considers the incus to be represented by the "hyomandibular" or "suspensorial" element. Mr. Parker, the author of the very splendid volume on the Shoulder Girdle issued last year by the Ray Society, has been examining this question of the lower jaw in Amphibians, and his researches lead him to agree with Professor Huxley's conclusions.

Muscular Homologies.—There are some important papers relating to this subject to be chronicled. Professor Rolleston, in a paper read to the Linnean Society, discusses the homology of certain muscles connected with the shoulder-joint; and in the Transactions of the same Society are very well-illustrated memoirs on the limb-muscles of the Six-banded Armadillo, and of the "Ard Vaak," or Cape Ant-eater. These three papers emanate from the Oxford Anatomical Laboratories. Professor Humphry has two papers on similar subjects (Myology of *Pteropus*, and of the Leg and Forearm) in the 'Journal of Anatomy;' whilst Dr. Macalister, of Dublin, has a third, on the Pronator Muscles in Vertebrate Animals. The general result of these papers is greatly to add to our knowledge of the muscular structures of Mammalia, and especially to give definite views on the serial homologies of the muscles of the fore and hind extremities.

The Vielle of the Seychelles.—This enormous fish, the *Batrachus gigas*, is occasionally caught by the fishermen of the above islands. Mr. Swinburne Ward, a resident in the Seychelles, writes that he has made repeated endeavours to procure a specimen to send to Europe, but it is exceedingly difficult so to do. The fishermen are sometimes obliged to cut the lines when a Vielle has been hooked, and on one occasion Mr. Ward was disappointed by the escape of a monster just as he had brought him to the surface. One has been known in the harbour for the last six years, lurking in a deep hole, as appears to be the habit of the species; and he refuses all snares and baits which are contrived to capture him. A head was sent recently to London by Mr. Ward, of a very large specimen, the greater part of which had been damaged; and he is now making continued efforts to obtain a good specimen. The fish is often as much as seventeen feet in length.

The Zandr, or Pike-Perch, is a fish resembling in external appearance both pike and perch, which is common in Eastern Germany, and is much eaten in Berlin, but is not known to the west of the Elbe. Mr. Frank Buckland has been making endeavours to procure specimens for naturalization in this country; and a dealer who recently went to Berlin to obtain specimens of the *Silurus glanis* for the reservoirs of a gentleman residing in Oxfordshire, brought over with him some specimens of this interesting fish. Herr Brockhardt has promised to send Mr. Buckland next spring a living zande of 11 or 12 lbs. weight, and also young zandes. The fish inhabits the lake-like expansions of the Naffel, Spree, and other rivers in North Germany, and is hence rather a lacustrine than a fluviatile species.

The Green Leech.—*Trocheta viridis* was first recorded as a British species some years ago by Dr. Gray, who had a specimen sent to him which was obtained in a very strange place, *viz.* Regent's Park. Mr. Henry Lee has lately rediscovered the species, and Mr. Pryor, of Trinity College, Cambridge, has also found it at Horsham in Surrey. The green colour was supposed by some persons to be possibly due to chlorophyl. Mr. Lankester, whose observations with the spectroscope first proved the presence of chlorophyl in the river Sponge, in Hydra viridis, and in a green worm (*Mesostomum*), finds upon spectroscopic examination that the green colour of *Trocheta* is not due to chlorophyl, but to a distinct green colouring matter soluble in alcohol, which also occurs in some marine annelids.

Impregnation of Balani.—In a recent Chronicle we noticed Fritz Müller's observations on South American Barnacles, which led him to believe that these animals are not only hermaphrodite, but capable of impregnating neighbouring individuals: and thus possibly in some cases a crossing of species might arise, which he was led to expect from the occurrence of forms apparently intermediate between species which live in adjoining habitats. Mr. R. Bishop, of Plymouth, records in the 'Annals' that he has seen copulation take place in a group of Barnacles which he was keeping in an aquarium. Great activity and excitement was exhibited by all the specimens, and they continually threw out a long tongue-like organ which penetrated adjacent individuals, and was clearly in his opinion an act of impregnation.

PHYSIOLOGY.

Action of Anæsthetics on the Blood.—Dr. J. H. McQuillen, of Philadelphia, has made a microscopical examination of the blood-corpuscles of animals killed by chloroform and by nitrous oxide, with a view of testing the assertion of Dr. Sansom, that chloroform destroys the red corpuscles. He finds that it undoubtedly does so when brought into contact with the blood after it has been drawn and placed on a glass slip, but that it certainly has no such effect in the body, nor has nitrous oxide, as he fully proves by experiment. Dr. McQuillen adds to this, that he considers undue prominence has been given by physiologists to the blood-corpuscles as *the* carriers of oxygen to the tissues, and carbonic acid gas to the lungs, and that it is reasonable to infer that the liquor sanguinis is engaged in this operation. But to what physiologists does he refer? Surely he cannot be acquainted with the modern researches and conclusions on this matter, for it is universally admitted, as the result of experiment, that a large part of the carbonic acid of the blood is held by the serum; indeed it has been a question if any is held by the corpuscles at all. Alexander Schmidt in a recent paper has shown that a variable amount is present in the corpuscles, whilst Sertoli and Zuntz have also been at work on the matter. The latter physiologist believes that a portion of the CO_2 of the blood is combined with carbonate of sodium and phosphate of sodium in the serum; the rest is in part merely dissolved, and in part retained, with a combination of potash and hæmoglobin in the blood-corpuscles.

Insusceptibility of Pigeons to Opium-poisoning.—Dr. Weir Michell, an able American physiologist, having occasion to produce sleep in pigeons, administered to them doses of various preparations of opium, but failed to produce the desired effect. Astonished at the failure, he made experiments with a view of seeing how much opium was required to kill these birds. He writes, "Pigeon took 80 drops of black-drop internally; no effect except a tendency to keep quiet; no signs of stupor; no change of pupils; feathers ruffled, as is common with these birds when sick from any cause. Pigeon received 42 drops of black-drop under skin of groin.

Symptoms the same as in the last case. Neither of them slept at all, and both were well the next day. Pigeon received under skin, in three localities in all, two grains of sulphate of morphia dissolved in water slightly acidulated with acetic acid. No effects were seen other than those described in the former cases. Pigeon took internally three grains of sulphate of morphia dissolved; recovery without notable symptoms. Pigeon took at 8.30 A.M. 272 drops of black-drop; he retained it during an hour, but at twelve was found to have vomited an unknown amount of it, by estimate at least half; recovered after remaining all day quiet in the corner of his cage, not asleep, and capable of being easily aroused, and then able to execute every usual movement, as flying, walking, and the like. The final experiment seems to me decisive. To a large pigeon, which within the two preceding days had swallowed 42 drops of black-drop, I gave, between two P.M. and six o'clock, 21 grains of powdered opium in soft pills of three grains each. Except the usual tendency to remain quiet, none of the common evidences of opium-poisoning appeared, and the pigeon was well and active next day."

Cause of Death when the Skin is covered with Varnish.—A writer in the 'Journal of Anatomy' observes that some persons have supposed that when an animal dies from the effects of having its skin covered with varnish, its death must be ascribed to the retention of deleterious matters given off by the skin. Edenhuizen thought that the noxious matter is volatile alkali. Gerlach and others thought that death was due to suppression of the respiratory functions of the skin; while Valentine had, on the other hand, shown that the morbid symptoms manifested by a varnished animal disappear if the animal be placed in a higher temperature, thereby leading to the notion that death in such a case results from increased loss of heat. Laschkewitsch, of St. Petersburg, has by recent researches confirmed the truth of the last-mentioned theory. A varnished animal, when surrounded by cotton-wadding, suffered no harm, though it died when the wadding was removed. He found the blood-vessels much dilated below the varnish; he supposes that the dilatation of cutaneous vessels favours the loss of heat by the skin. He has found that the volatile alkali spoken of by Edenhuizen results from the decomposition of hair and epidermis. He further disproved Gerlach's view that asphyxia is the cause of death, by placing an animal in an atmosphere of hydrogen, taking care to cover the animal's mouth with an elastic funnel communicating with the external atmosphere. The animal lived in this medium for six hours withont suffering any deleterious effects.

MISCELLANEOUS LITERATURE, &c.

Prof. Huxley's New Book.—A book on the classification of animals by Prof. Huxley has just been published, and must be of great value to those reading for examinations, as well as to students and teachers. It is an extension of the lectures published in a former volume, which also included lectures on the skull. The orders as well as the larger groups of the animal kingdom and the *principles* of classification are discussed in this book, which is undoubtedly the most advanced and most trustworthy manual of the outlines of comparative anatomy yet published.

The Journal of Anatomy.—We desire cordially to recommend this excellent journal, published half-yearly, to such of our readers as are interested in the advancement of physiology and anatomy. Professors Humphry and Turner are ably carrying on their undertaking, begun in 1867, but we can well believe that a more extended circulation would be to the advantage of all parties concerned. The reports on the progress of anatomy by Professor Turner, and on various departments of physiology by Drs. Gamgee, Rutherford, and Fraser of Edinburgh, and Dr. Moore of Dublin, are among the most useful and complete records of biological literature that are published in any language.

Quarterly List of Publications received for Review.

1. British Conchology; or, an Account of the Mollusca which now Inhabit the British Isles and the surrounding Seas. Vol. V. Marine Shells, and Naked Mollusca to the end of the Gastropoda, the Pteropoda, and Cephalopoda, &c. (conclusion of the work). By John Gwyn Jeffreys, F.R.S., &c. *Van Voorst.*
2. A History of the British Hydroid Zoophytes. By Thomas Hincks, B.A. 2 vols. *Plates.* *Van Voorst.*
3. A Practical Treatise on Metallurgy, adapted from the last German Edition of Professor Kerl's Metallurgy. By Wm. Crookes, F.R.S., and Ernst Röhrig, Ph.D. Vol. II. Copper—Iron. *With* 273 *Wood Engravings.* *Longmans.*
4. Sound and Colour: their Relations, Analogies, and Harmonies. By J. D. Macdonald, M.D., F.R.S. *Longmans.*
5. On the Chemical Changes of Carbon. By Wm. Odling, M.B., F.R.S. (A Course of Lectures.) Reprinted from the 'Chemical News.' With Notes by W. Crookes, F.R.S. *Longmans.*
6. On the Principles of Pure and Applied Calculation, and Application of Mathematical Principles to Theories of the Physical Forces. By Rev. James Challis, M.A., F.R.S., &c. *Cambridge: Deighton, Bell, & Co. London: Bell & Daldy.*
7. Iron and Steel. By Knut Styffe, Director of the Royal Technological Institute at Stockholm. Translated by C. P. Sandberg, with a Preface by John Percy, F.R.S. 9 *Lithographic Plates.* *John Murray.*
8. Habit and Intelligence. By Joseph John Murphy. 2 vols. *Macmillan & Co.*
9. On Going to Sleep. By Charles H. Moore. *R. Hardwicke.*
10. Croonian Lectures on Matter and Force. By Dr. Henry Bence Jones, F.R.S. *J. Churchill & Sons.*
11. Reliquiæ Aquitanicæ. Part VIII. *Bailliere.*
12. Die Chemie der Jetztzeit. C. W. Blomstrand, Prof. an der Universität zu Lund. *Heidelberg: C. Wintersche Buchhandlung.*
13 La Storia Antica, Restituita a Verita e Raffrontrata alla Moderna. Dal Commendatore Negri Cristoforo. *Torina: Stamperia dell' Unione Tipografico-Editrice.*
14. Spectrum Analysis. By Henry E. Roscoe. *With coloured Plates and Illustrations.* *Macmillan & Co.*

15. Cyclopædic Science Simplified. By J. H. Pepper. *With six hundred Illustrations.* *Warne & Co.*

16. Sound: a Course of Eight Lectures, delivered at the Royal Institution of Great Britain. By John Tyndall, LL.D. F.R.S. &c. *Longmans & Co.*

PAMPHLETS AND PERIODICALS.

Discoveries in Science by the Medical Philosopher. By Sir G. Duncan Gibb, &c. *H. K. Lewis.*

On the Conditions of the Metallic Currency of the United Kingdom, with reference to the Question of International Coinage. By W. Stanley Jevons, M.A.

On the Structure and Affinities of Parnassia palustris, &c. By Alf. W. Bennett, M.A., B.Sc.

London Water Supply. By H. H. Fulton, C.E.

On the Action of Nitrites on Blood. By Professor Gamgee.

Reports of the Mining Surveyors and Registrars. *Victoria.*

A Problem for Trisecting an Angle geometrically, &c. By Sampson Sandys.

Statistics of New Zealand.

The Mineralogy of Nova Scotia. By Henry How, D.C.L.

Report on the Culture of the Japanese Silkworm in England. By Alexander Wallace, M.D., &c.

Of Geological Dynamics. By Sir William Thomson, LL.D. F.R.S. Reprinted from the 'Transactions of the Geological Society of Glasgow.' Vol. III. Part 2.

Colorado: United States, America; its History, Geography, and Mining. By R. O. Old. *London.*

Nekrosozoic Process for the Preservation or Embalming of the Human Body. Reports of Dr. Francis Delafield, Professor James R. Wood, Professor R. Ogden Doremus, Professor A. Flint, jun. *Garstin & Co.*

The Disinfectant Question. Reprinted from the 'Sanitary Record.' *London.*

Quarterly Notes on Books. *Longmans.*

Revue Bibliographique Universelle,* June, 1869. *Paris.*

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* This Review contains, besides Notices of Books in all languages, a list of all important works in Theology, Jurisprudence, the Arts and Sciences, Philosophy, Politics, Education, Industry, Finance, and Commerce, the Fine Arts, Belles Lettres, Novels, History, &c.; also the contents of all noteworthy periodicals published in the French, German, English, Dutch, Italian, Polish, Russian, &c., languages.

Van Nostrand's Eclectic Engineering. No. VI. *New York.*
The American Naturalist, June, 1869. *Salem, Mass.*
The Educational Gazette.
The Geological Magazine.
Scientific Opinion. Part VII.
The Popular Science Review.
The Westminster Review.
The Chicago Medical Times. Vol. I. No. 3.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Third Annual Report of the Aëronautical Society of Great Britain. President: The Duke of Argyll. Hon. Sec.: F. W. Brearey.

The Journal of the Historical and Archæological Association of Ireland.

Transactions of the Geological Society of Glasgow.

Proceedings of the Bristol Naturalists' Society.

" " Miners' Association of Cornwall and Devonshire. By R. Hunt, F.R.S., Hon. Gen. Sec.

Report of the Rugby School Natural History Society.

Bolletina della Societá Geografica Italiana (with President's Address). *Firenze: Guiseppe Civelli.*

Journal of the Ethnological Society of London. Edited by Professor Huxley, F.R.S., President. Hon. Sec., Lionel J. Beale, M.R.C.S.

Address at the Anniversary Meeting of the Royal Geographical Society, May 24, 1869. By Sir Roderick Impey Murchison.

Proceedings of the Royal Institution.
" " Royal Society.
" " Royal Astronomical Society.
" " Zoological Society.
" " Bath Natural History and Antiquarian Field Club. No. 3.

In the present Number (XXIII.) of this Journal will be found, besides numerous Short Notices of Books, Pamphlets, and Essays, Reviews of the following recent works on Scientific subjects:—

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Moore's 'Going to Sleep' (*Hardwicke*)	401
Somerville's 'Molecular Science' (*Murray*)	403
Odling's 'Chemical Changes of Carbon' (*Longmans*)	405
Fergusson's 'Illustrations of Mythology and Art in India' *	410
Becquerel's 'Influence of Forests on Climate' †	446

* In Chronicle of Archæology. † In Meteorological Chronicle.

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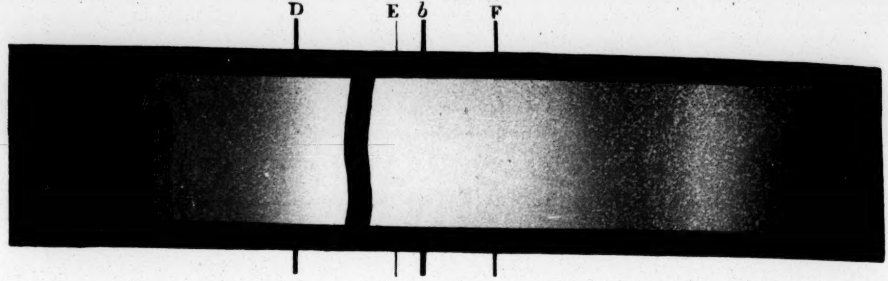
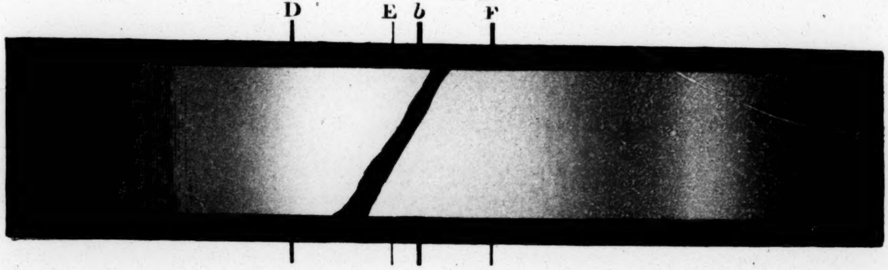


Nº 2.



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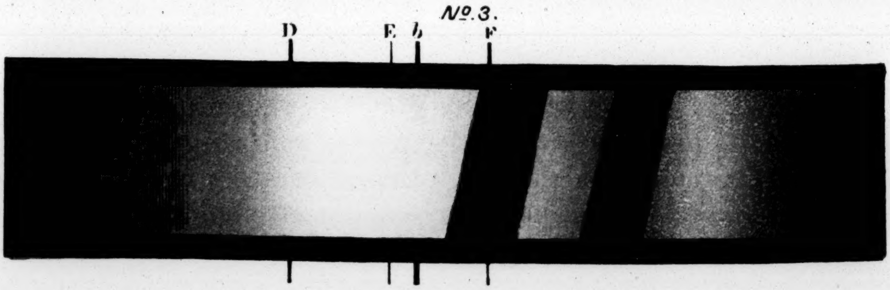

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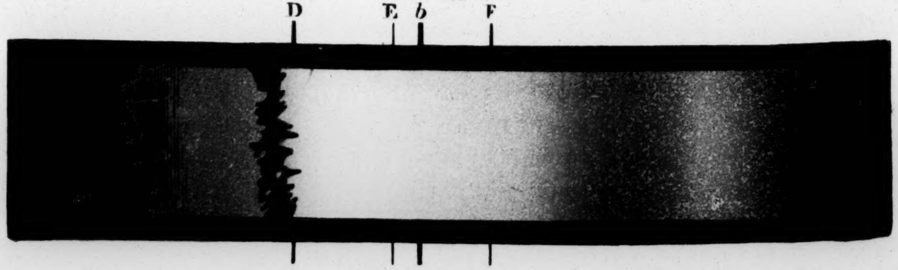

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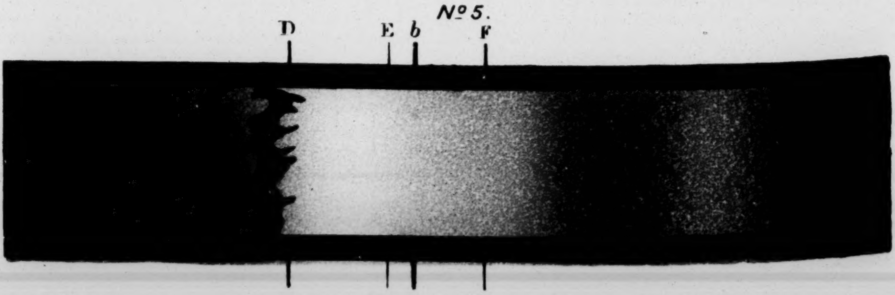

SPECTRAL PHENOMENA OF OPALS.

By William Crookes F.R.S. &c.